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Mineralogical Examination of Some Soils from South-Western Australia.

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This paper gives the results of the first of a series of co-operative soil studies to be undertaken by the Department of Agriculture and the Government Chemical Laboratories in order to provide fundamental information about Western Australian soils.

INTRODUCTION.

Broadly speaking, a soil consists of mineral matter, derived from the weathering of rocks, and organic matter, derived from plants and animals, together with water and air. Numerous plants and animals, ranging in size from the smallest bacterium to large earth-worms, live in the soil if the climatic and topographic conditions are favourable; these are included as a definite part of the soil by some soil scientists. The mineral matter consists of particles of weathered rocks, stones, gravel, sand, and clay. Used in this sense the term "mineral" should not be confused with the common agricultural usage which unfortunately describes various chemical elements the presence or absence of which in soils affects plant and animal growth. Strictly speaking, a mineral is a substance having a definite chemical composition, generally formed by inorganic processes, and possessing a definite crystalline form. Rock crystal (quartz) is an example of a mineral which exhibits its crystalline form and is fairly common. Rocks are made up of minerals which have either crystallised as a solid mass from molten rock material, e.g., lava, or have been compacted together by sedimentary or metamorphic processes. Sandstones and schists are examples of rocks formed by the latter two processes.

This present investigation deals with mineral particles of sand grade between 0.2 and 0.14 mm. in diameter (between 60 and 90 mesh I.M.M.), of the surface nine inches of soil. These sand grains represent the remains of original minerals in the parent rock or rocks of the soil. The grains, although very fine, have been more or less resistant to chemical weathering. The mineral grains present in the soil therefore give an indication of the type of rock which has been broken down to form soil. The minerals in the parent rock which weather more readily by chemical action change into the clay part of the soil and to such secondary minerals as limonite and indefinite iron-aluminium compounds.

Some soils are more fertile than others; that is, they produce better quality crops and healthier stock. This fertility depends to a large extent, provided the physical properties are satisfactory, on the chemical elements which are avail-

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able for plant growth. These elements are supplied by the minerals of the original parent rock and by the remains of plants and animals in the soil. In Western Australia there are extensive areas in which the soils have developed more or less directly from the rocks beneath them. Such soils are known as sedentary soils. There has been very little mixing of soil material from different sources or origins such as occurs in soils formed on materials of alluvial origin, e.g., river-flat soils and flood-plain soils. Sedentary soils will thus closely reflect the variations in composition of the underlying rocks, a fact of considerable importance when it is known that some of the rock types are deficient in those minerals associated with an abundant supply of elements required for the nutrition of plants and animals. Because of this lack of mixing, sedentary soil types can often be recognised mineralogically even when of similar outward appearance. Such soils may differ in the content of certain minerals important in nutrition as sources of required minor elements. Mineralogical examination may be of value in the recognition and differentiation of such soils, and in pointing to major agricultural differences. In fact, mineralogical examination of soils from the wasting disease country at Denmark, combined with a knowledge of the geology, has shown important differences between affected and sound farms which are adjacent.

There are many areas in this State in which deficiency of copper or cobalt is known to occur. From examination of the mineral grains in the sand fraction of some of these soils it has been possible to suggest reasons for this. It is known that the useful minor elements, such as copper and cobalt, are associated with certain kinds of minerals present in the rocks of the earth's crust. (This association does not include segregations of ore-bearing minerals in which the concentration is sufficiently high for the ore to be processed for the production of metals.) If then these "useful" mineral grains are present in adequate amounts it is reasonable to suppose that the soil will supply the associated elements which are required by the plants and animals living on the soil and drawing their nutriment from it. Details of the association of minor elements and the reasons for this association have been given elsewhere (Carroll, 1941). Examples important in Western Australian agriculture are copper and cobalt, which are generally associated with the dark silicate minerals such as amphiboles, pyroxenes and olivine. The associations depend on a number of factors, one of the most important of which is the atomic structure of the mineral and the ionic size of the elements entering into the combination to produce a mineral. Micas also have atomic structures which enable small quantities of such cations as cobalt, nickel and copper to enter into the structure. Such cations are released by weathering and chemical disintegration of the host minerals and are then available for plant nutrition. It must not be supposed, however, that every dark coloured silicate mineral will contain the important minor elements, for their presence will depend on the chemical composition of the molten rock material from which they have crystallised out. Silicates can also crystallise in metamorphic rocks, and their composition will then depend on the chemical elements present in the sedimentary or igneous rocks which have been subjected to heat and pressure in order to form these types (schists are metamorphic rocks).

It has been found that certain types of rock, conveniently termed "basic" because of their low silica contents, are relatively rich in minor elements. Recent research work on the minor elements of a series of intrusive basic rocks of East Greenland (Wager and Mitchell, 1943) shows that the various minor elements are associated with several stages in the differentiation and consolidation of the original rock material. Chromium and nickel were concentrated in the first rocks to solidify, vanadium in the early middle stage, copper and lithium in the later middle stage, while molybdenum, zirconium, thorium, lanthanum and rubidium are concentrated in the last rock to solidify, a granitic type.

The south-western part of Western Australia used for agriculture consists of gneisses, schists, granites and greenstones of the Pre-Cambrian complex with some younger sediments. So far as this investigation is concerned the soil fertility is largely connected with the inorganic soil constituents which vary according to the composition of the parent rocks. In general, soils with a high clay content (implying either alluvial origin or a high degree of weathering of the parent rocks) and soils derived from basic igneous and volcanic rocks are of higher fertility than the more sandy types of soil. The results of the survey of the copper status of clovers grown on various types of soil (Teakle and Turton, 1943) indicate that soils can be classified for copper status as follows:—

Low (copper, up to 3 ppm.). derived from sediments, *eg.*, Gingin and Dandaragan; and certain types of granitic rocks, *e.g.*, Margaret River, Pardelup

Sub-normal and low normal (copper, 3 to 7.5 ppm.): derived from granitic and gneissic types of rocks.

High normal to rich (copper, 7.5 to 15 ppm. and over): derived from dolerites, basic schists, basalts, and some types of granite and gneiss.

The object of this paper is to give the results of mineralogical examinations of soils collected from a number of sites in the Swan Littoral Region, the Darling Peneplain Region, the Irwin Region, the Avon Region, and the Dwarda Region. The copper status has already been obtained for clovers grown on the large majority of these soils, and only in one or two places have copper-containing fertilisers been used. A list of these soils is given in Table 1. The distribution of the soils is shown in Figure 1, Teakle and Turton, 1943.

THE SOILS EXAMINED.

From a knowledge of the geology of the South-Western part of the State and from field observations, the soils included in this examination fall into three main groups:—

(1) Soils on the recent alluvial and outwash zone west of the Darling Scarp (Swan Coastal Plain) *e.g.*, at West Swan and Bullsbrook.

(2) Soils on the Cretaceous greensand and chalk; *eg.*, Gingin and Dandaragan.

(3) Soils on Pre-Cambrian granites, gneisses, schists, basic dykes, etc., *e.g.*, Bindoon, New Norcia, Walebing, Waddington, Berkshire Valley, Yericoin, Calingiri, Calcarra, Culham, Coondle, Toodyay, Baker's Hill, Kojedda, Wooroloo.

(1) The soils of the Swan Coastal Plain at West Swan and Bullsbrook have been derived from the weathering and denudation of the western edge of the Darling Scarp and represent material which has been deposited fairly recently (geologically) and is probably for the most part of mixed parentage. During sedimentation in the later stages, action of the Swan River has caused variation in the resulting sediments and soils, some being more sandy and some more clayey than others. In addition, there are older sediments, but the boundaries between the recent Swan alluvial soils, the outwash soils, and those formed from somewhat older sediments have not been mapped.

2. The Cretaceous sediments are a series of more or less horizontal beds of greensand and chalk (limestone). The greensands (an upper and a lower bed have been distinguished) consist essentially of quartz sand and a green mineral, glauconite, which on weathering alters to limonite, quartz, and indefinite compounds. The soils produced are therefore sandy. On the chalk a black, clayey soil, rich in organic matter, and known as a rendzina, is formed. In the Cretaceous country all the sandy soils of both the Gingin and Dandaragan districts are

derived from the greensands. Shales underlie the lower bed of greensand at Gingin, and a somewhat different type of soil is produced. Much of the rolling, scrub-covered, sand-plain country between Dandaragan and Moora is probably derived from a sandstone overlying the upper greensand.

All the Cretaceous sediments are of marine origin, *i.e.*, the beds were laid down in the sea some distance from the shore. The materials which are now the greensands were originally derived from the land by denudation of a previous land surface, and therefore have been through at least one cycle of erosion from solid parent rock, to weathered rock, to soil, to stream or river sands, to marine sediments. The sediments as they are today are the result of an uplift, whereby the sea-floor has been raised to dry land. Erosion has again set in, and the land has become dissected by streams, *e.g.*, the Minyulo Brook, and has been carved into hills and valleys. The chalk between the greensand beds is largely a chemical deposit which may have been due to a cessation of sedimentation for a certain period of time, probably to be measured in many thousands of years.

3. Within the area underlain by Pre-Cambrian rock some of the soils are associated with granites, gneisses, and metamorphosed sediments, whereas others result from the weathering of basic rocks such as dolerite, epidiorite, hornblende schists, etc. One important soil type is that formed on the lateritic gravels of the relatively undenuded Darling Peneplain, *e.g.*, soils at Wooroloo. Where the lateritic capping has been removed in the dissected parts of the peneplain, the soils have developed on the underlying country rock. The removal of the lateritic capping is largely a result of erosion of the peneplain surface by the Swan-Avon and Moore River systems. The soils developed on the undissected parts of the area, *e.g.*, at Bindi Bindi (1000 ft. above sea-level), Piawaning (821 ft.), Yericoin (857 ft.), Calingiri (818 ft.), and Calcarra (851 ft.) are apparently on the unaltered peneplain surface. These soils are thin, sometimes of the sand-plain type, and have the appearance of being much older than the soils of the more deeply dissected parts such as those between Bindoon and New Norcia, and in the Berkshire Valley.

MINERALOGICAL EXAMINATION.

The sand grains of the 60 to 90 I.M.M. grade (0.2-0.14 mm. in diameter) consist of individual grains of a number of different minerals, each of which has a definite chemical composition, and physical and optical properties. The commonest constituent of the sand is generally quartz (with varying quantities of felspar and the larger grains of clay minerals), but there are also grains of other minerals, some of which may be very important in identifying the type of rock from which the soil has developed. As some grains are heavier than others, a concentration of the heavy grains can be made by mixing the sand with a heavy liquid (bromoform, specific gravity, 2.9) in which the heaviest will sink and the lightest grains float on the surface. The percentage of heavy fraction, *i.e.*, the grains which sink in the liquid, is given for this series of soils in Table I, from which it will be seen that the heavy fraction ranges from 0.4 per cent. to 69 per cent. of the fine sand used for the separation. As magnetite (magnetic iron ore) is often a constituent of the heavy fraction, it is removed by a magnet, thus further reducing the bulk of grains which have to be identified by microscopic examination. An estimate of the percentage of the different mineral species present in the non-magnetic fraction is made visually, or if time permits, by counting and identifying about 500 grains in each heavy fraction.

The reason why so much attention is paid to the minerals of the heavy fraction is that among the heavy minerals there is generally a fairly large variety of minerals which are characteristic of certain types of rock, whereas the quartz and felspar of the light fraction are of ubiquitous occurrence.

MINERALOGY OF THE SOILS.

The minerals recorded in the sand fraction of this series of soils are:—

Mineral.	*Composition.*	*Derivation.*
Heavy fraction.		
Magnetite	Fe_3O_4	Many types of rocks.
Limonite	$Fe^{III}(OH)O$.	An alteration product of other minerals.
Ilmenite	$FeTiO_3$ (+ Fe_2O_3).	Many types of rock.
Rutile	TiO_2	Gneisses, granites, some greenstones.
Zircon	$ZrSiO_4$	Granite, gneiss.
Tourmaline	Complex borosilicate of Al with Mg, Fe, Li, etc.	Granite, gneiss, pegmatite.
Ferromagnesian minerals.		
Amphibole group	Complex silicates of Mg, Fe, Ca, with Na & Al	Epidiorites, schists, gneisses.
Pyroxene group	Complex silicates of Mg, Fe, Mn, Ca, Na, Li, Al	Dolerites, some epidiorites.
Epidote (& zoisite)	$HCa_2(Al, Fe)_3Si_3O_{13}$	Some types of greenstones and granites.
Micas	Silicates of Al, K with Mg, Fe or Li, OH and F	Granite, gneiss, schists, metamorphic rocks.
Kyanite	$Al_2O_3.SiO_2$	Schists, gneisses.
Sillimanite	$Al_2O_3.SiO_2$	Schists, gneisses.
Andalusite	$Al_2O_3.SiO_2$	Schists, gneisses.
Staurolite	$HFe^{II}Al_5Si_2O_{13}$	Schists, gneisses.
Garnet	Al. silicate with Mg, Fe, Mn, Ca, Cr, in various replacements	Schists, gneisses and some types of greenstone.
Spinel	$MgAl_2O_4$	Metamorphosed sediments; ultra-basic rocks.
Sphene	$CaTiSiO_5$	Granites, gneisses, some greenstones.
Monazite	$(Ce_2, La)PO_4$	Granite, pegmatite.
Light fraction.		
Quartz	SiO_2	Granites, gneisses, metamorphosed sediments.
Felspar	Silicates of Al with K, Na, Ca	Granites, gneisses, pegmatites, meta-sediments, greenstones.
Glauconite	$KMgFe^{III}(SiO_3)_6.3H_2O$	Greensand and chalk.
Clay, iron, and aluminous aggregates	Variable	Alteration products of other minerals.

All or any of these minerals may be present in sedimentary rocks such as the Cretaceous greensand and chalk.

When examining the minerals in heavy residues it is often found that there is considerable variation in the physical appearance of a mineral, *e.g.*, zircon in the lower greensand at Gingin may have quite a purplish colour, whereas zircon from another locality may be clear and colourless, or clear and contain numerous black specks. It is not proposed to discuss here these very important varietal features but they take a definite part in the interpretation of heavy mineral results, particularly if the investigation is dealing with the mineralogy of a series of bedded sediments.

The distribution of the minerals recorded in these soils is given in Table I. The results may be summarised thus:—

(a) Heavy residues of soils derived from the Cretaceous sediments are characterised by the abundance of limonite, ilmenite, and iron ores generally, and by remnants of detrital minerals which have been derived from pre-existing igneous and metamorphic rocks and incorporated in these sediments along with quartz. The limonite largely results from the alteration of glauconite.

(b) The heavy residues of soils derived from Pre-Cambrian rocks, and which have developed more or less *in situ* can be divided into two sub-groups:—

(1) Characterised by the abundance of ferromagnesian minerals (amphiboles, epidote, and sometimes pyroxene). These minerals indicate a derivation from epidiorites, dolerites, basic schists, and basic gneisses.

(2) Characterised by the abundance of zircon, tourmaline, rutile, and sometimes kyanite and andalusite, with subordinate amphibole and epidote, which show derivation from granitic and gneissic rocks and some types of metamorphosed sediments.

The figures for copper status of subterranean clover grown on the soils have been added in Table I. Soils from two localities, Mungedar (Dandaragan) and Gingin, have received copper dressings so that the mineralogical results have no significance with regard to copper status. The mineralogy of these soils shows, however, that they are similar to other soils in the same areas.

On examining the data given in Table I it is seen that there are a number of residues which contain appreciable amounts of the ferromagnesian minerals amphiboles, pyroxenes, and epidote. Subterranean clover grown on the majority of these soils has a normal to high copper status. This influence on the copper status seems to be made by the ferromagnesian minerals, or more exactly, by the type of rock which gives these minerals in the soil heavy residues. There do not appear to be any other minerals in the residues whose influence would be shown in this way. Recent research work on the minor element content of ferromagnesian minerals (Wager and Mitchell, 1943), following the lead given by Goldschmidt and his colleagues at Oslo has shown that it is the ferromagnesian minerals in which the majority of the trace elements known at present to be of particular importance in plant and animal nutrition occur.

A comparison of the copper status of subterranean clover samples grown on the natural soils with the ferromagnesian content (estimated with a microscope) of the fine sand heavy residues can be tabulated as follows:—

Ferromagnesian mineral content of heavy residue.	Copper status of subterranean clover samples.				
	Rich, over 15 ppm.	High normal, 7·5 to 15 ppm.	Low normal, 4·6 to 7·5 ppm.	Sub-normal, 3 to 4·5 ppm.	Deficient, 0 to 3 ppm.
	No. of Samples.	No. of Samples.	No. of Samples.	No. of Samples.	No. of Samples.
8+	12	5	...	...	...
8	3	...	...	...	...
7+	1	...	...	...	...
7	1	2	1	...	...
6	2	4	1	...	...
5	1	...	2	1	1
4	1	...	1	...	1
3	...	1	1	...	1
0	1	1	4	...	4
Totals	22	13	10	1	7

Note.—The figures given for the quantity of ferromagnesian minerals have been arbitrarily chosen and do not signify percentages ; they are estimates based on microscopic examination.

It will be seen from this tabulation that in the rich and high normal copper groups there are 17 residues with a ferromagnesian content of 8+, 3 with 8, and 10 between 6 and 7+. In other words, 86 per cent. of the soils in these two groups have a ferromagnesian content of 6 and over, and of these, 57 per cent. were in the 8 and 8+ group.

The origin or parent material of the 35 soils in the rich and high normal groups is:—

	Alluvial and Colluvial.	Granitic.	Gneissic.	Basic Rocks.	Cretaceous Sediments.
No. of soils	12	2	8	12	1

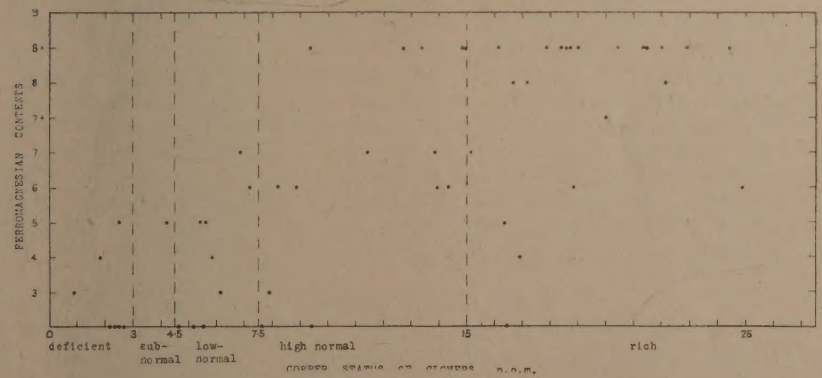
Soils classed as alluvial and colluvial include those which are considered to have moved slightly from their place of origin. Many of these have been derived wholly or in part from basic rocks.

The origin or parent material of the 18 soils in the low normal to deficient groups is:—

	Alluvial.	Granitic.	Cretaceous Sediments.
No. of soils	1	8	9

The relationship between the ferromagnesian mineral content of the heavy residues and the copper status of the subterranean clover grown on these soils is illustrated in Figure 1.

Fig. 1.—Ferromagnesian mineral content of the heavy fraction of soils compared with the copper status of clovers grown on these soils.



(Note.—Explanation of ferromagnesian figures is given in Table 1.)

DISCUSSION.

In the interpretation of the mineralogical analyses it may appear that too much stress has been given to the ferromagnesian minerals, and that an examination should be made of all the mineral grains present in a soil. Previous experience has shown that the sand grade yields better material for microscopic work than any other grade, and comparison can be readily made of a number of samples which have all been treated in the same way. The ferromagnesian minerals residual in the heavy fraction of a fine sand may indicate that the soil has been more or less directly derived from basic rocks, and it is now known that basic rocks, by

reason of the minerals which compose them, are richer in important minor elements than are granitic rocks. The rôle played by essential and non-essential minerals in rocks must be recognised: a mineral may be non-essential or accessory in one type of rock and yet, because it is highly resistant to weathering, it may make up a large percentage of a soil's heavy residue. Such minerals are zircon, tourmaline, kyanite, staurolite, and sillimanite.

The mere presence or absence of a mineral in the heavy residue of a fine sand in itself has little significance, but each mineral species gives a clue which is important to an understanding of the make-up of a soil. Thus it is recognised that basalt forms a soil of high fertility owing to the ready weathering of the essential minerals, and the heavy residue may contain only a few grains of augite (an essential constituent of basalt), a very misleading occurrence if the significance of the clay fraction is not fully appreciated. By contrast, the accessory heavy minerals of some rocks, *e.g.*, zircon in granite, are very resistant to weathering and can pass through many cycles of sedimentation before being "worn out" or completely disintegrated. In consequence, such minerals will be concentrated in the heavy fraction, and without careful consideration mineralogically mere estimation of the quantity present would be similarly misleading.

The climatic and topographic conditions under which a soil developed will also leave their mark on the mineralogy of the heavy residue. Any rock weathering in a moist climate will give a different kind of soil from that which is produced under arid conditions.

CONCLUSIONS.

This investigation shows that the "heavy minerals" with specific gravity of 2.9 and over in the sand fraction of soils give a useful means of recognising soil parentage for a number of Western Australian soils. There is good correlation between the ferromagnesian mineral content of the sand residues and high normal to rich copper status of subterranean clover grown on these soils. The tentative generalisations made by Teakle and Turton (1943) with regard to copper deficient soils have been strengthened. In Western Australia geological and topographical knowledge is necessary to a full interpretation of soil conditions and this can best be attained by field-work and by heavy mineral examinations of the soils. The vast majority of soils in the peneplain region of the South-West appear to have developed *in situ*, and a mineralogical examination gives information of value to the soil scientist and to the agriculturalist.

ACKNOWLEDGMENTS.

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TABLE I.

HEAVY MINERALS IN FINE SANDS OF SOILS EXAMINED.

Sample No.	Farmer.	District.	pH.	Cu status ppm.	† Heavy Fraction. %	† Magnetic Fraction. %	Minerals Present in Heavy Fraction.																Description of Soil and Country.
							Ilmenite, Limonite, etc.	Rutile.	Zircon.	Tourmaline.	Ferro-Magnesians. Amphibole.	Epidote and Zoisite.	Pyroxene.	Mica.	Kyanite.	Sillimanite.	Andalusite.	Staurolite.	Garnet.	Titanite.	Spinel.	Monazite.	
208	Marshall	W. Swan	5·77	15·1	·6	·14	8	4	4	4	6	6	....	....	7+	4	?	7	....	....	....	....	Grey yellow sand ; paper-bark, jarrah, marri.
221	Marshall	W. Swan	5·77	5·5	3·0	·2	8	4	4	4	....	....	....	....	7	4	6	6	3	....	3	....	Grey sandy soil ; jarrah, marri, paper-bark.
89	Copley	Bullsbrook	5·46	8·2	1·3	·7	8	6	6	4	4	6	....	....	6	4	....	6	....	....	....	....	Yellowish brown sandy loam ; marri, wandoo.
211	Rennie	Gingin	5·57	5·1	9·0	1·3	8+	....	4	4	....	....	....	....	....	....	4	....	....	....	....	....	Red loamy sand and gravel ; marri.
209	Rennie	Gingin	6·40	2·2	1·4	·5	8+	5	5	4	....	....	....	....	6	4	4	6	....	....	....	....	Reddish brown sand ; marri, banksia.
....	Rennie	Gingin	5·41	....	2·5	1·1	8+	4	6	4	....	3	....	....	4	....	6	4	....	....	....	....	Reddish brown loam.
....	Rennie	Gingin	5·51	....	3·9	1·5	8+	4	4	3	....	....	....	....	3	....	....	....	....	....	....	....	Reddish brown loam.
....	Brown	Dandaragan	5·58	....	·9	·3	8+	4	5	4	....	....	....	....	4	4	....	4	....	?4	....	....	Grey brown diatomaceous loam ; bluegum.
119	Brown	Dandaragan	6·42	2·2	2·0	·8	8+	5	4	....	....	....	....	....	4	....	....	....	4	....	....	....	Reddish loose sandy soil ; marri, banksia.
120	Brown	Dandaragan	6·48	1·8	1·6	·6	8	5	6	4	4	....	....	....	4	4	....	4	4	3	....	....	Dark brown loamy sand ; yorkgum, marri.
121	Brown	Dandaragan	6·04	6·1	1·5	·7	8	6	6	....	....	3	....	....	5	4	....	5	....	....	....	....	Dark brown loamy sand ; yorkgum.
....	Brown	Dandaragan	6·02	....	4·5	·8	8+	5	4	....	....	....	....	....	4	4	....	4	....	....	....	....	Dark brown loamy sand.
125	Yathroo	Dandaragan	5·64	2·3	·6	·3	8	4	5	4	....	3	....	....	4	4	....	3	3	....	....	....	Dark grey loamy sand ; bluegum.
....	Yathroo	Dandaragan	8·04	....	1·6	·9	8	4	5	5	3	3	....	....	5	....	....	4	4	4	....	....	Black loam, chalk fragments.
124	Yathroo	Dandaragan	5·63	16·2	·6	·1	8+	....	4	4	....	....	....	....	6	....	....	5	....	....	....	....	Brown sand, clay subsoil ; bluegum.
126	Yaodabbie	Dandaragan	6·22	4·6	·6	·1	8+	4	4	....	....	....	....	....	6	....	4	5	....	4	....	....	Brown sand on red with gravel ; marri, banksia.
127	Yaodabbie	Dandaragan	5·47	7·3	·4	·1	8	5	7	6	....	....	....	....	7	....	....	5	....	4	....	....	Sand soak land.
....	Kyanaba	Dandaragan	5·94	....	1·4	·3	8+	4	5	3	....	....	....	....	5	4	....	4	....	....	....	....	Brownish grey sandy loam.
128	Mungedar‡	Dandaragan	6·46	16·1	·4	·1	8	6	6	4	....	....	....	....	7	4	....	4	....	4	....	3	Brown sand ; marri.
129	Mungedar‡	Dandaragan	6·56	12·5	·4	·1	8	6	6	6	....	....	....	....	7	4	4	4	....	....	....	....	Brown sand on red sand ; marri, wattle.
131	Mungedar‡	Dandaragan	6·21	6·5	·5	·3	8	6	6	5	....	....	....	....	6	4	....	4	....	....	....	3	Black-brown loam on yellow brown clay at 5 inches.
....	Mungedar‡	Dandaragan	6·81	....	1·4	1·0	8	6	7+	4	....	....	....	....	7+	5+	....	4	....	4	....	4	Reddish brown sand.
95	Stephens	Bindoon	6·25	21·3	69·0	49·0	8	....	....	....	8	6	7	....	....	....	....	....	....	....	....	....	Red gravelly loam ; marri.
96	Stephens	Bindoon	5·61	22·0	2·0	·4	6	....	3	4	6	8	3	....	....	....	....	....	....	....	....	....	Brown loam, alluvial ; marri.
97	Christian Bros.	Bindoon	5·73	24·8	11·0	9·0	8	4	4	4	....	6	....	....	....	....	....	....	....	....	....	....	Red loam ; yorkgum, wandoo.
98	Moore	New Norcia	6·26	13·9	·9	·4	8	6	6	3	....	6	....	....	3	3	....	5	....	3	....	....	Yellow brown fine gravel, sandy loam, reddish clay subsoil ; marri.
99	Clune	New Norcia	6·00	16·1	·8	·6	8	5	8	6	6	7+	?	....	4	....	....	6	4	....	3	....	Brown loamy coarse sand ; yorkgum, marri.

TABLE I.—*continued.*

HEAVY MINERALS IN FINE SANDS OF SOILS EXAMINED.

Sample No.	Farmer.	District.	pH.	Cu status ppm.	† Heavy Fraction. %	† Magnetic Fraction. %	Minerals Present in Heavy Fraction.																Description of Soil and Country.
							Ilmenite, Limonite, etc.	Rutile.	Zircon.	Tourmaline.	Ferro-Magnesians. Amphibole.	Epidote and Zoisite.	Pyroxene.	Mica.	Kyanite.	Sillimanite.	Andalusite.	Staurolite.	Garnet.	Titanite.	Spinel.	Monazite.	
100	Clune	New Norcia	5·45	16·6	1·9	1·5	7	4	4	4	8	8	?	....	....	....	....	....	6	....	....	....	Brown loamy coarse sand ; yorkgum, marri.
101	Clune	New Norcia	6·34	14·9	4·9	1·3	6	....	....	....	8	6	....	....	....	....	....	....	....	....	....	....	Brown gritty loam, dolerite outcrops ; yorkgum.
102	Clune	New Norcia	5·88	20·4	·9	·5	7	4	5	4	8	6	?	....	4	4	....	....	....	....	....	....	Dark brown loam ; floodgum.
103	Bened. Comm.	New Norcia	5·77	20·0	·4	·2	8	4	6	4	6	6	....	....	....	....	....	4	4	....	....	....	Brown loamy sand ; jam.
104	Edgar	New Norcia	6·08	14·8	·6	·4	8	5	8	5	7	7	....	....	4	....	....	....	4	....	....	....	Brown loamy sand ; jam and yorkgum.
105	Edgar	New Norcia	6·00	7·2	·5	·1	8+	5	8	6	4	5	....	....	....	....	....	....	....	....	....	....	Yellow brown sand ; wandoo, stinkwood, tamma.
106	Saleeba	Waddington	6·34	4·2	1·4	·3	8+	4	7	4	4	4	....	....	3	....	....	....	....	3	....	....	Brown gravelly loam soil ; wandoo, yorkgum.
107	Saleeba	Waddington	5·70	14·3	·5	·3	8	6	8	6	....	6	....	....	4	4	....	....	....	....	....	....	Brown gritty loamy sand ; jam.
108	Essex	Waddington	5·87	18·7	·7	·4	6	....	4	3	4	8	?	....	3	....	....	....	....	3	....	....	Light brown gritty loamy sand ; jam, yorkgum.
109	Cross	Walebing	5·94	9·4	1·4	·6	7+	3	4	8	....	....	....	....	4	3	....	....	....	....	....	....	Yellow grey gravelly sand ; wandoo, jam.
134	Cross	Walebing	6·71	11·4	·8	·4	7	4	6	4	6	6	....	3	3	....	....	3	....	3	....	....	Yellow grey sand, some gravel, granite outcrops ; wandoo and scrub.
110	Cross	Walebing	6·89	13·8	1·1	·5	8+	4	4	6	6	4	....	....	....	....	....	3	....	3	....	....	Yellow brown gravelly loamy sand ; wandoo and scrub.
111	Lefroy	Walebing	5·91	17·1	5·1	4·7	8	....	8	4	6	7	6	....	....	....	....	....	....	?	....	....	Rich red brown sandy loam, dolerite ; jam and wandoo.
112	Sandland	Walebing	5·82	18·4	·9	·2	6	....	3	....	6	8	....	....	....	....	....	....	3	....	....	....	Red brown loamy sand ; jam.
116	Kelsall	Berkshire Valley	6·16	19·0	14·6	·7	4	....	....	....	8+	....	....	....	....	....	....	....	....	....	....	....	Rich brown heavy loam, dolerite ; yorkgum.
117	Kelsall	Berkshire Valley	5·40	24·4	·5	·3	6	4	4	3	8	8	....	....	....	....	....	....	4	....	....	....	Brown loamy sand, gneissic ; jam.
115	Kelsall	Berkshire Valley	6·96	21·3	1·1	·4	7	....	3	....	8	8	....	....	....	....	....	....	....	....	....	....	Light brown to brown loamy sand ; jam, sheoak.
114	Kelsall	Berkshire Valley	6·18	22·2	·5	·2	6	....	4	....	8	....	....	....	....	....	....	....	....	....	....	....	Brown sandy loam to sandy clay loam ; yorkgum, salmongum.
113	Kelsall	Berkshire Valley	5·88	12·7	·6	·2	7	4	6	....	8	6	....	....	....	....	....	....	7	4	....	....	Light brown gritty sand ; jam.
138	Duggan, J. J.	Yericoin	6·87	16·3	·3	·1	8	4	6	5	5	....	....	....	4	....	6	....	....	4	....	....	Brown sandy loam ; morrel, salmongum.
136	Duggan, J. J.	Yericoin	6·38	5·8	·2	·03	7+	5	8+	5	4	....	....	....	4	....	4	....	....	4	....	....	Gravelly heath country.
137	Duggan, J. J.	Yericoin	8·14	18·8	1·4	·9	8+	5	6	4	5	....	....	....	4	....	....	3	....	....	....	....	Light brown loam ; salmongum.
139	Duggan, A. R.	Yericoin	6·00	16·9	·3	·1	8	5	8	5	4	....	....	....	5	4	3	....	....	....	3	....	Greyish yellow sand, some gravel ; wandoo, tamma.

140	Duggan, T. P. W.	Yericoin	....	6·10	7·8	·6	·2	8+	3	5	4	3	....	....	....	4	4	3	3				Very gravelly sand; wandoo, parrot bush.
141	Halse	Calingiri	....	6·00	5·3	·3	·1	8	4	8	7	5	....	....	....	4	....	4	....	....	3		Yellow brown gravelly sand: wandoo, jam, scrub.
142	Lindsay	Calcarra	....	6·35	8·8	·7	·2	8	....	8+	4	5	5	....	....	....	....	3	3			4	Brown grey gritty sand near salty creek
143	Phillips	Culham	....	6·32	13·3	5·0	2·8	5	....	4	....	8+	8										Dark brown loamy sand, clay subsoil, granitic, doleritic, boulders.
144	Phillips	Culham	....	6·54	18·6	2·3	·5	6	....	4	....	8	8										Dark brown loamy sand on yellow clay; jam, yorkgum.
145	Lee Steere	Coondle	....	6·48	22·8	2·1	·06	6	....	3	....	8	8+										Dark brown to red brown loamy sand on yellow stony clay.
146	Groves	Toodyay	....	5·94	17·8	1·4	·03	5	3	3	....	8+	8										Grey brown heavy sandy loam.
147	Groves	Toodyay	....	5·86	9·3	9·5	1·9	5	....	....	....	8+	6										Brown loamy sand brown gritty clay at 12 inches; jam.
....	Cuming Smith	Bakers Hill	....	6·23	....	·5	·07	7	4	6	....	5	8+	....	....	....	....	....	....	3			Brown grey loam: granite or gneiss outcrops adjacent.
148	Tognolini	Bakers Hill	....	6·44	6·9	·6	·1	8+	....	6	....	4	6										Grey to brown yellow gravelly sandy loam on yellow subsoil.
149	Tognolini	Koojedda	....	6·50	5·4	·7	·2	8+	....	3	....	4	4										Brown grey sandy loam, wandoo, marri.
150	Sanatorium	Wooroloo	....	6·15	2·5	·7	·2	8+	4	6	....	4	....	....	....	3	....	....	....	....	3		Brown grey gravelly sand: jarrah, casuarina.
....	Sanatorium	Wooroloo	....	6·40	....	1·3	·4	8+	....	4	3	4	....										Brown grey gravelly sand.
152	Sanatorium	Wooroloo	....	6·66	2·6	·6	·2	8+	....	7	....	....	....	....	....	4	3	3					Grey gravelly loamy sand.
153																							
151	Sanatorium	Wooroloo	....	6·66	0·9	·8	·4	8	3	5	....	....	3	....	....	3	....	....	....	....	....		Yellow grey gravelly loamy sand; jarrah, marri.

* Copper status of clover leaves (Teakle and Turton, this Journal, Vol. 20 (second series), No. 3, 1943).

† Per cent. by weight of fine sand.

‡ Land treated with copper-containing fertilisers.

Frequency Scale.

The figures given for the heavy minerals have the following significance:

8+ Very abundant in the heavy residue.
8 Abundant.
7+ Very common.
7 Common.
6 Rather scarce.
5 Scarce.
4 Very scarce.
3 Few grains only present.
? Doubtful identification.

The Use of Wheat for Dairy Cows.

M. CULLITY, Superintendent of Dairying, and
N. McKEOWN, Agricultural Adviser.

During recent months much attention has been focused on the use of wheat as a concentrate for the feeding of dairy stock. At no previous period have farmers been so interested in the relative merits or demerits of this foodstuff when compared to the much more widely used mill offals such as bran and pollard.

The cause of this interest may be ascribed to the greatly increased quantities of concentrates being used by stock feeders due both to increased prices making such a course of action profitable and also to make good the deficiency of paddock fodders occasioned by the particularly dry summer which has just been experienced. Unfortunately, although the flour mills throughout the State are working at full pressure, there has been insufficient bran and pollard to meet farmers' requirements. It was this position and the great necessity for not only maintaining but increasing the production of dairy commodities that has brought wheat into the limelight as a suitable grain for the milking cow.

The idea is by no means an innovation. This department has advocated the judicious use of crushed wheat in rations for dairy cows wherever such feeding yielded a profitable margin over cost for many years, but the difference in price between wheat grain and mill offals was in the past a deciding factor in favour of the use of the latter foodstuffs in dairying areas. Now, however, with the advent of cheap wheat and higher prices for dairy products any economic objection to the use of wheat has been greatly reduced and in view of the shortage of mill offals it is a relatively happy outlook for dairymen that such an effective substitute is available.

The essential qualities required in any stock food are:—

(1) Economy.
(2) Nutritive value.
(3) Palatability.
(4) Freedom from harmful after effects.

An examination of the following table will show that wheat is a cheap, highly nutritious, easily digested concentrate, and is rightly considered as one of the best foodstuffs available.

Fodder.	Food Values per 100 lbs.		Monetary Values.			
	Starch Equiv.	Protein Equiv.	Price Quoted May, 1944. Per ton (2000 lb.)	Cost per Food Unit.		Value based on Present Price of Wheatmeal @ £7 5s. per ton. (2000 lb.)
				Protein Equiv.	Starch Equiv.	
			£ s. d.	pence.	pence.	£ s. d.
Pollard... ...	69	10·6	6 0 0	6·80	1·04	6 19 7
Bran	44	9·9	6 0 0	7·27	1·64	4 8 9
Wheat (cr.) ...	72	8·0	7 5 0	10·88	1·21	7 5 0
Oats (cr.) ...	62	7·6	8 5 0	13·03	1·60	6 5 0
Barley (cr.) ...	71	6·8	8 0 0	14·12	1·35	7 3 0
Oaten Chaff ...	42	3·5	8 5 0	27·29	2·10	4 6 7
Wheaten Chaff	31	3·0	8 15 0	35·00	3·03	3 10 0

In the above table the relative food values and money values, including the prices at which they were quoted on 22nd May, 1944, the cost per food unit at these prices and the actual value of these fodders, based on the actual price of crushed wheat are shown.

It is seen from this table that pollard is the cheapest stock food quoted daily with crushed wheat in second place. Bran is actually dear but valued on account of its general physiological effect. These estimated values are based solely on the starch equivalent (the net energy value of the fodder) the protein equivalent has not been taken into account and therefore an allowance must be made for this factor.

Wheat has certain distinct characteristics which definitely influence its use as a foodstuff. Primarily it is a starchy food having a nutritive ratio of 1 : 7 (i.e., the ratio of digestible protein to digestible non-protein is as 1 to 7). This is a little wide for milk production and therefore some protein rich supplement is desirable, except where ample leguminous roughage or vigorously growing pasture are available.

However, under Western Australian conditions it is possible to provide either pasture of good quality or clover hay all the year, except in dairies located in the metropolitan area, where full hand feeding is practised. Where the protein content of the ration is low it may be improved by using linseed meal or one of the protein-rich proprietary stock foods which are available. The amount of supplement would depend on the quality of the main part of the ration.

The mineral content of wheat should also be noted. Although Australian wheat is lower in phosphorus than the European or American grain it is still comparatively rich in this element and apart from performing its essential physiological functions in the animal body will also contribute its quota to maintaining the phosphate status of the soil. It should be remembered, however, that phosphorus is only one of the elements added to the soil by a system of grain feeding and the general manurial advantage accruing to the soil through this practice should not be overlooked.

On the other hand, wheat is markedly deficient in lime and as calcium is of primary importance to the lactating and growing animal care must be taken to ensure that this deficiency is made good either by feeding ample leguminous roughage or a calcium supplement such as dicalcic phosphate or bonemeal, alternatively quicklime may be slaked in the drinking water. The palatability of crushed wheat depends almost entirely on the coarseness of crushing and the manner in which the crushed grain is fed. The first essential is that the meal should be of coarse or medium texture and never finely ground. In the latter case it will form a pasty, unpalatable mass in the animal's mouth due to the high flour content. Palatability is further increased by mixing the crushed grain with concentrates such as bran, crushed oats, linseed meal and pollard, or feeding it with roughages such as clover hay, and cereal or flax boll chaff. Victorian practice has shown that when chaff is scarce and expensive as little as one pound to every four pounds of crushed wheat will ensure the necessary degree of palatability and digestibility in the feed (1).

Bearing in mind the foregoing facts which should strongly commend the use of wheat to dairymen in the feeding of their herds it must still be recognised that a definite prejudice exists against the use of wheat for this purpose. Such prejudice is not now as strong as it was a year ago, but nevertheless, it is still there.

Fundamentally the reason lies in No. 4 (listed above) of the essential qualities looked for in a stock food—freedom from harmful effect. Two possible evils are anticipated. It is common knowledge that wheat contains a poisonous principle capable of causing founder in horses and it is therefore feared by many that the same substance may affect cows. This fear, however, is not substantiated by practice as long as the change to a wheat diet is not made too suddenly and the initial quantities fed are not too great. It should be remembered that even horses may be fed large quantities of wheat grain with impunity, once they are accustomed to the ration. Sudden changes of diet are always liable to cause digestive disturbances and it would only be common sense to commence feeding wheat in small amounts, gradually increasing the ration to the maximum desired. European experiments have shown that the liberation of the toxic principle in the stomachs of horses when fed large quantities of wheat is favoured by a fairly high acid condition of the stomach. The buffering of this acidity by the addition of 2-3 per cent. of ground limestone in the ration appears to prevent any trouble. It is possible that the same condition is responsible for the toxic effect in cows when fed large quantities of wheat too suddenly, it is therefore thought advisable where wheat constitutes more than one third of the grain ration to add 2-3 per cent. of ground limestone as a precautionary measure.

An alternative disadvantage has been suggested in that crushed wheat may prove very difficult of digestion, as it tends to aggregate into glutinous masses impermeable to digestive juices and impeding regurgitation (chewing of the cud). This appears a possibility where wheat constitutes the bulk of the concentrate ration and is not fed in conjunction with much roughage. However, interesting experiments carried out in U.S.A. indicate that even under such unusual feeding conditions, trouble from this reason is not likely to occur. The rumen or first stomach of the cow is a very muscular organ capable of quickly disintegrating "boli" or aggregates of sticky food, the food eaten in the bails being quickly mixed with the roughage collected in the field. At Michigan Agricultural Research Station (2) equal parts of linseed meal and ground corn (this mixture when moistened forms a most cohesive mass) were fed to cows which were slaughtered at varying intervals after ingesting the food. The rumens were examined and although no roughage was given and the mixture is considered unusually "heavy" hardly any "boli" remained in the rumen at the end of one hour. This being the case, one can hardly expect that crushed wheat, fed in moderation and with other foodstuffs, would prove unduly tenacious and indigestible when fed to cows.

Information from local farmers supports the view that lack of satisfaction in the use of wheat as a dairy feed and failure to use it to a greater extent is due almost entirely to faulty handling of the material. There is very little doubt that a very large part of the trouble experienced with feeding crushed wheat is caused by a sudden change of diet rather than any unsuitability of the product. Farmers who have been accustomed to using bran and pollard finding supplies insufficient to enable them to feed in their normal quantities have been loth to use the stock meal and frequently have not introduced it to their cows gradually mixed with their other foodstuffs, but have delayed until their normal feeds are exhausted and then introduced the wheatmeal. The change was apparently too sudden and frequently has caused indigestion with other upsets including a reduction in the milk flow. Farmers who have introduced it first as a small part of the ration and then gradually increased the amount over a period until frequently it has been fed alone, have met with success. As far as can be ascertained no difficulty has been experienced by those farmers who used it as a part only of a concentrate mixture. As long ago as 1933, Mr. A. P. Herbert of Nungarin had been feeding wheat to his stud Jersey cattle for a number of years and benefited this Department by a report on his personal experience.

The "Nooka" herd was tested officially for over two years, hence both production and feeding methods have been checked. Crushed wheat was the basal constituent of Mr. Herbert's concentrate ration, which consisted of equal parts of crushed oats, crushed wheat and bran. At various times when bran has been difficult to procure and when the supply of oats has been low, wheat alone has been fed to the cows (along with roughage) without any diminution in the milk yield. As much as eight pounds of crushed wheat has been fed per head per day without any apparent deleterious result. "Nooka" cows under official test produced remarkably well when tested during the long, dry summer and one must assume that the use of wheat has contributed in no small measure to the success attained. And surely if the use of crushed wheat will result in evil after-effects, Mr. Herbert would have obtained evidence thereof during the long period he has been using this foodstuff.

More recent reports which have been furnished by Field Officers of this Department since the shortage of mill offals became acute are also informative. The following are experiences on different farms where wheatmeal has been fed.

(a) Herd of 20 cows.

Ration changed suddenly from 6-9 lb. bran daily to same amount of crushed wheat. Cows became sick and production dropped considerably. The only pasture available was largely scrub. Cows recovered when half the wheat was replaced with bran.

(b) Herd of 10 cows.

The following daily ration was fed:—8 lb. crushed wheat, 2 lb. bran, 1 lb. pollard, 4 lb. oaten chaff, 1 kerosene tin chaffed maize, 2 teaspoonfuls copper sulphate, 2 oz. dicalcic lick in addition to poor dry pasture and scrub. The cows milked well and were in good condition throughout.

(c) Another farmer fed for a period of six months at the rate of a kerosene tin of a mixture of ½ bag crushed wheat to one bag of chaff, plus linseed for milking. He claims that in that period he received from the same cows 1,000 lb. of butterfat more than he did in the same six months of the previous year when pollard was used in place of wheat.

(d) One farmer used up to 8 lb. per head per day with meatmeal or linseed meal as available, fed in the bails, with long hay in the paddock after milking. Results were quite satisfactory with no ill-effects over a period of six months.

(e) Herd of 50 cows.

This farmer continued feeding wheatmeal to his cows even when increased quantities of mill offals became available. He had been using the meal for six months and was quite satisfied with the meal, either fed alone or with linseed meal. The cows were started with linseed and wheat and for two months linseed was unobtainable and wheat alone was fed with good results. When linseed was re-introduced butterfat returns showed a slight increase. The mixture used was 1 bag coarse crushed wheat, 1 bag (150 lb.) linseed meal, fed at a rate of 2.3 lb. per day with 3-4 lb. meadow-hay chaff.

General comments from officers who conducted this survey showed that where coarse-crushed wheat had been introduced gradually and used in conjunction with a protein rich supplement and roughage, no injurious effects had resulted and the farmers were, in the main, quite well satisfied.

At the Denmark Research Station where the herd average is in the vicinity of 400 lbs. of butterfat, not adjusted, wheat has been fed in a concentrate mixture for at least the past eight years. Up to 8 lbs. of wheat per head per day has been fed in a mixture made up as follows:—

180 lb. wheat
120 lb. oats.
50 lb. linseed
12½ lb. meatmeal.

The concentrate mixture is fed in the bails without any roughage. Silage from mixed grasses and clover is usually fed in the paddock in February and March at the rate of 15 lb. per head per day; when maize is available it is used at the same rate during the months of February, March and April; approximately 20 lb. per head per day of hay is available during June and July. For the remainder of the year the herd draws all of its roughage from pasture consisting of subterranean clover, perennial rye grass, some Phalaris tuberosa and some Yorkshire fog. The wheat was ground on the farm to a medium degree of fineness.

One or two of the highest producing cows showed a tendency to get trouble with their feet; this occurred only during the hot weather; no loss of appetite has been observed and during the period only about three cows had sickness which could be attributed to the wheat. There is no doubt that when used as described above the wheat has been quite palatable. It has been included in the ration at the Research Station because of the ease of supply and its relatively low cost.

Since the demand for mill offals outstripped the available supply, crushed wheat has been advocated rather more as a supplement to bran and pollard than as a complete substitute.

To produce products which could be mixed with the mill offals without altering their characteristics, millers in this State have for the last 15 months been letting wheat for stock feed go to what is known as the "first break" stage which produces a much more attractive looking cow feed than the ordinary crushed wheat. This procedure has now been modified by the introduction of special crushing rollers in a section of the mill separate from the flour milling. These rollers are similar to the "first break" rolls and operate on conditioned wheat. The crushed product can be separated over a bran sieve into two fractions—coarse and fine—which have been named branato and pollato respectively to indicate an affinity to bran and pollard and yet to make a clear distinction between the substances. Since the shortage of bran is more acute than the shortage of pollard the crushing before sieving is designed to produce more branato than pollato and this is accomplished by a light crushing (the rolls used are fluted and set relatively widely apart) of conditioned wheat, that is wheat which has been dampened.

At present the sieve separation provides some three to four times as much branato as pollato. The branato has physical properties very similar to bran and the pollato is very similar to pollard and the technique yields a remarkably small amount of fine floury material in the pollato.

It is not intended that these materials should be fed alone as a general practice but should be mixed with bran and pollard respectively. It is difficult to distinguish by eye the difference between bran and a mixture of three parts by weight of bran with one part by weight of branato and similarly for pollard and a three to one pollard-pollato mixture.

SUMMARY.

1. Wheat is at present prices an exceedingly cheap foodstuff; it is nutritious, palatable and easily handled.

2. Where wheat is first used in small quantities, it does not appear that evil effects will follow its use.

3. As much as 8 lb. of crushed wheat has been fed per day to high producing cows in this State without obvious harmful results.

4. Only use wheat to the extent of a maximum of half the concentrate ration, until experience warrants its use in larger proportions.

5. Wheat is a starchy food with albuminoid ration of one to seven.

6. Wheat is rich in phosphates but deficient in lime. Cows on a cereal diet need some additional supply of lime which can be obtained from clover pasture or clover hay.

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Snails and Slugs.

C. F. H. Jenkins, Government Entomologist.

DISTRIBUTION AND GENERAL DESCRIPTION.

Two species of snails are common in this State, the Brown or English snail (*Helix aspersa*) and the White or Italian snail (*H. pisana*). Slugs are also only too well known. The latter may be roughly described as snails without a shell and as the habits and control measures described for snails will apply in the main essentials to slugs, they need receive no further mention.

The European snail reached this country many years ago, and is now practically world wide in its distribution. The first record for Australia comes from New South Wales in 1888, but the exact date of its arrival in this State is not known. The white snail is a later arrival in this State and is believed to have been transported in ships' ballast from South Africa, where it is a well-known pest. Bunbury and Albany contend for the doubtful honour of being the first site where this snail was established locally. Its distribution at present is essentially coastal, and in situations where it is firmly established it far outnumbers the larger brown snail. So alarming was the rate of increase of this snail in portions of California that an extermination campaign was undertaken in 1922 and the results were eminently successful.

The brown snail is the larger of the two species, the full-grown shell being formed of from four to four and a half whorls or coils and measuring an inch or more in diameter. The shell of the white snail may attain a diameter of from a half to three-quarters of an inch.

The food of the snail consists both of living plants and dead or decayed vegetation, and they also show cannibalistic tendencies if any of their squashed brethren are available. The snail has no true jaws, but rasps its food by means of a tongue-like structure or radula covered with teeth like a file, the suitability of which for disposing of vegetable material few gardeners will question.

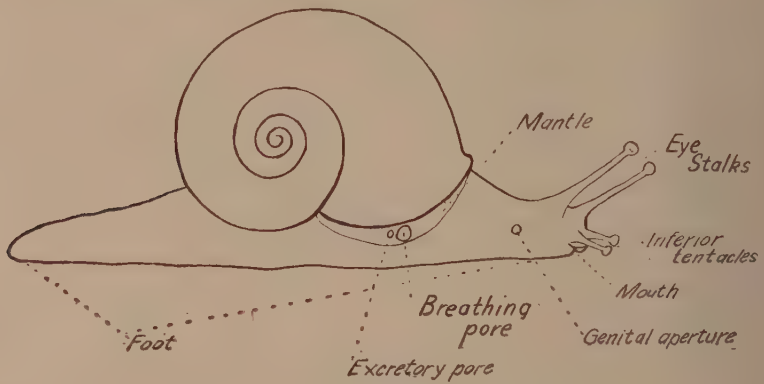


Diagram of Snail. (After Basinger.)

Habits.

The nocturnal habits of the brown snails are well-known to all who have surveyed with dismay their surviving seedlings the morning after the night before. The white snail is not so retiring in its habits and can be found feeding in the day time.

The liking of snails for moisture and shelter is also general knowledge, and should be remembered when attempting control measures. Masses of weeds and a tangle of creepers against walls and fences always form a dangerous harbourage for snails.

During adverse weather conditions, either dry or cold, the snail becomes inactive and seals off the entrance of its shell with a kind of diaphragm. Under our summer conditions this prevents excessive loss of moisture and enables the creature to survive even when exposed in clusters on twigs and fences as so frequently the white snail is seen to be.

When this feature of the snails' habits is remembered there need be no astonishment at the sudden appearance apparently from nowhere of armies of snails immediately following the first autumn rains.

Experiments in South Africa showed that out of 50 snails of both species collected in January, 1919, and placed in jars of soil without food or artificial moisture six brown and three white snails revived and fed on cabbage leaves at the end of March, 1921. That is after a dormant period of over two years.

When the shell of the snail becomes injured it can be repaired to a remarkable degree. New shell will be built over the places where sections have become detached, but the original markings are not reproduced, so that the repair work will always remain apparent.

Brown snails clustered on citrus tree trunk during dry weather. (After Basinger.)

Life History.

There is no differentiation of the sexes in snails, as each individual possesses the male and female organs, and so is called hermaphroditic. During mating mutual fertilisation takes place and both individuals may lay eggs. A suitable spot is selected in a damp, sheltered situation, and a hole about an inch or more in depth is dug. The eggs are coated with a slimy mucilage which causes them to cling together and swell when moistened. A single snail may lay a number of times and produce several hundred eggs. On hatching the young snails are furnished with a tiny white shell, and feed gregariously for some time, but when a few months old they lead a more individualistic life. The period required for the eggs to hatch is about a fortnight under good conditions, but this period may be greatly increased by dryness or excessive cold. The rate of growth is relatively slow, for it takes over a year for the full size to be reached.

CONTROL.

Metaldehyde mixed with bran has proved one of the most effective slug and snail baits yet devised. In this State the most readily obtainable form of metaldehyde is a heat fuel tablet sold under the name of "Meta." Unfortunately this commodity is now rather difficult to obtain owing to war conditions. The recommended formula is:—

Baits.

Small quantity—

Meta, ½ ounce.
Bran, 1 lb.
Water, 1 pint.

Large quantity—

Meta, ½ lb.
Bran, 16 lbs.
Water, 2 gallons.

Where Meta is unobtainable a very effective substitute is available in calcium arsenate, and the following bait will be found very useful:—

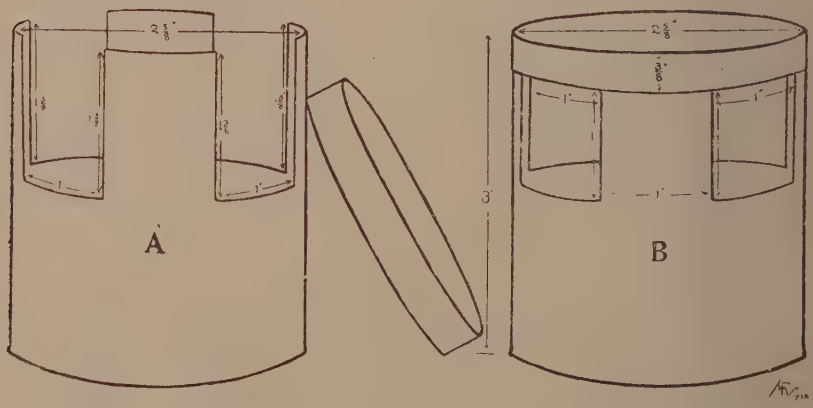
Calcium arsenate, 1 oz.
Bran, 1 lb.
Water, 1 pint.
Honey or molasses, 2 tablespoons.

It has been shown that where very bad infestations have to be dealt with the inclusion of ½ ounce of Meta in the latter bait in addition to the calcium arsenate is more effective than either of the poisons used alone.

Arsenite of soda may replace calcium arsenate where this is not to hand, but will be found to give inferior results.

In preparing these baits the poison should be ground to a fine powder and thoroughly mixed with the bran. The amount of water recommended should not be rigidly adhered to, as it is only necessary to moisten the bait so as to make a loose, crumbly mash. The bait may be distributed broadcast, or placed here and there in small heaps.

Bait Container.—In order to preserve the bait from being washed away during rainy weather, it may be placed in small tins cut according to the accompanying diagram.



A bait container made from a cigarette tin. The lid is replaced as shown in B so that the bait does not become diluted by rain.

(After Corbett.)

Dusts.

Slaked lime is widely recommended for use against snails and slugs, but its efficiency leaves much to be desired. The addition of powdered copper sulphate (bluestone) or copper carbonate, to the lime, however, makes a very toxic dust. This cannot be recommended for the actual treatment of plants, but where a plot of ground is endangered by invasions of snails from adjacent breeding grounds, a barrier of lime and copper dust will be found invaluable. Should the creatures succeed in crossing the barrier they will succumb very rapidly. The formula recommended is:—Copper sulphate or copper carbonate, 1 part; slaked lime, 12 parts.

Cultural Methods.

Every effort should be made to control weed growth in the vicinity of the garden, and where thick hedges are grown the old leaves and debris should be collected and got rid of.

Digging the soil in these sheltered spots would also reveal a large number of egg clusters, the destruction of which will greatly reduce future infestations. The importance of clean cultural methods cannot be over-emphasised in the control of all garden pests, and well repays any energy expended in this direction.

ACKNOWLEDGMENTS.

Corbett, G. H.: *Malayan Ag. Jnl.*, Vol. XXVI., No. 9, Sept., 1938, p. 376.
Basinger, A. J.: *Univ. Calif. Bull.* 515.

Strychnine Supplies.

Strenuous efforts have been made over a considerable period to obtain supplies of strychnine from overseas for the destruction of rabbits and other pests. Unfortunately, the source of supply in the United Kingdom is no longer available, but we are pleased to report that arrangements have been made for obtaining supplies from India. Progressive deliveries will be made, the first of which is expected to arrive within the next week or so.

Under the auspices of the Chamber of Commerce, three firms have agreed to supply distributors who were not formerly their clients but relied upon importations from the United Kingdom. Accordingly, all previous channels of distribution should be covered, and if the three prime distributors share out each consignment equitably to all normal distributors, under the undertaking given to the Chamber of Commerce, a wide and general cover should follow.

An amount of 174,400 ounces of strychnine material has been ordered; 69,760 ounces will be supplied as strychnine alkaloid, and 104,640 ounces as crude Brucine-strychnine mixture containing not less than 43 per cent. strychnine. Experiments have been conducted in Australia with this latter material with results comparable to results with strychnine alkaloid.

The 174,400 ounces will, in the main, be discharged at Syney and Melbourne where the principal repacking facilities exist, but small advance quantities will also be landed at Adelaide and Fremantle. Accordingly, supplies will have to be sent from Melbourne and Sydney to the other four States, but the above basis of distribution should ensure as far as practicable that all States receive their supplies through normal trade channels.

It is felt that control under National Security (Agricultural Aids) Regulations is not necessary, particularly when satisfactory distribution can be achieved by the method set out above.

Farmers generally will be glad to know that the Government's efforts to relieve the present shortage of strychnine have been successful.

Two Sheep Problems on Subterranean Clover Dominant Pastures.

1.—LAMBING TROUBLE (DYSTOKIA) IN MERINOS.

2.—PROLAPSE OF THE WOMB (INVERSION OF THE UTERUS).

H. W. BENNETTS.

During the past three seasons two problems, dystokia and inversion of the uterus, have caused increasingly severe losses in sheep throughout the areas where early subterranean clover dominates the pastures.

Both conditions have a similar general distribution, from Wannamal in the north to Tambellup, Kojonup and Bridgetown in the south, the region just west of the Great Southern Railway being particularly affected. Within this area the distribution of the two conditions varies. Commonly both occur together on the same properties, but either condition may occur singly on many. Dystokia does not appear to be a problem in the more northerly areas.

Investigations carried out since 1943 have so far failed to reveal the actual cause of either condition although it is now known that neither is of infectious origin.

It is considered that nutritional factors are largely responsible for both. There is one factor common to all properties where any notable losses from dystokia and inversion of the uterus have been known to occur. This is dominant luxuriant early subterranean clover pasture. The information to date strongly suggests that this factor is in some way responsible for the recent serious occurrence of these problems.

This statement may at first appear rather anomalous. As is well known, clover pastures were established and grazed in these areas for many years with a resultant great increase in the productivity of improved properties. Why, it may be asked, was no serious trouble experienced prior to 1941?

On present evidence it appears that seasonal conditions offer a partial explanation. It will be remembered that 1941, 1942 and 1943 were unusually good seasons, favourable to clover dominance and resulting in luxuriant pastures and, in general, in an early and prolonged green period. This was especially so in 1943 when green feed was available from February onwards in many districts. There was evidence too that the occurrence of dystokia and inversion of the uterus corresponded with the variation of seasonal conditions within the affected area. Their incidence tended to be greatest in those districts where seasonal conditions were most favourable for pasture growth during that particular year.

It is of interest to note that no identical problems have been reported from other parts of Australia. It has been stated also that pastures comparable with those of our affected areas do not occur elsewhere in the continent, the local conditions being especially favourable for early subterranean clover dominance.

The nature of the apparent relationship of our pasture conditions to the occurrence of the two problems under investigation is being studied further. The main purpose of this article is to give a brief account of these problems and to suggest alterations in management which may act as palliatives pending the results of investigations now in progress.

1.—DYSTOKIA IN MERINOS.

In its strict sense the term dystokia means difficult birth. This may result from a defect in the mother or some abnormality of the foetus (unborn young). As is well known, this complaint is quite common. In any flock it may be necessary, for various reasons, to assist a number of ewes to deliver their lambs. Where there is great disparity in the size or conformation between the dam and sire (*e.g.*, Merino x Romney Marsh) cases of dystokia may be frequent.

In this article, however, dystokia is not used to describe such cases but is used in a much more restricted sense to describe a specific problem with certain characteristics.

This dystokia is characterised by the non-evidence of the usual signs of lambing and the death of the full term foetus. It is confined almost entirely to the merino ewe, lambing of crossbreds running under identical conditions generally being satisfactory. Maiden four tooths are most susceptible, but ewes of any age from two tooth onwards may be affected.

ERRATA.

Vol. XXI (Second Series), No. 2, June, 1944.

Page 105, line 33, substitute the following:—

In some instances, the full-term lamb is born dead; usually, however, the

Pages 106-7:—

The portion of the foot-note on page 106 commencing "In the early stages" should be read after line 26 on page 107.

Page 134, line 13:—

Delete the word "floor."

We may now describe the manifestations and results of the dystokia in more detail.

In most instances when attention is drawn to the ewe the lamb has been dead* ewe after a brief and half-hearted attempt to lamb rejoins the flock and for some time gives little evidence that it is in trouble. Such ewes are missed, even when the flock is kept under careful observation. No part of the lamb due to be born is visible externally. It is some days later before attention is drawn to the ewe, which is then carrying a dead lamb, by any of the following features:—

The protrusion of the nose or forefeet of the lamb, or of a portion of afterbirth, or the presence of a functioning udder which may be greatly distended with milk. At this stage and subsequently ewes may strain at frequent intervals. Ewes carrying dead lambs will sometimes attempt to foster newly born lambs.

In most instances when attention is drawn to the ewe the lamb has been dead* for some days and great difficulty is experienced in delivering it on account of its dryness (large size) and the apparent contraction of the uterus. Quite commonly

* The death of the lamb, in these cases, is ascribed to factors which come into operation when birth is unduly delayed.

the operation results in a complete prolapse of the womb (not to be confused with the inversion of the uterus, which is the second problem to be discussed) or in the death of the ewe from handling, etc. If delivery is not accomplished the foetus putrifies and there is a stinking discharge. The sheep strains frequently, has a humped posture and loses condition. Ultimately it may recover although still carrying a mummified foetus which can be felt in the abdomen. In some cases this actually finds its way through the abdominal wall to the exterior.

Naturally such ewes do not get in lamb again. There is evidence too that others from which dead lambs have been removed also become infertile, presumably as a sequel to the inflammation of the womb resulting from putrefaction of the foetus. There are thus indirect lambing losses as well as those directly due to the dystokia.

As mentioned in the introduction although the actual cause of dystokia is unknown present evidence suggests that it is of nutritional origin and that favourable seasonal conditions were largely contributory to the recent increased occurrence. Two factors were obvious in affected flocks investigated in 1943 (a) ewes were in very fat sluggish condition and (b) lambs were commonly unduly large, full term dead foeti weighing from ten to fourteen pounds. The normal weight of a merino lamb at birth is about eight pounds. (See Underwood, Shier and Beck, 1940.)* The dystokia was at first ascribed to the operation of one or both of these factors. More recent information, however, seems to suggest that there is some factor in addition to high bodily condition which prevents normal labour in the ewe.

Further observations and experiments are being carried out in an attempt to get at the fundamental cause of the dystokia.

2.—PROLAPSE OF THE WOMB (INVERSION OF THE UTERUS).

Individual cases of protrusion, or prolapse of the womb, may be seen in farm animals shortly before or soon after giving birth to the young, the prolapse occurring under various circumstances which give rise to excessive straining at those periods. We have referred already to prolapse as a sequel to dystokia in merino ewes. These conditions do not concern us here.† The problem to be considered is a prolapse of the womb in ewes which occurs typically *some months after the lambing season.* It generally proceeds to a complete turning inside out of the womb, viz., inversion of the uterus.

About five per cent. of the ewes in a flock are commonly affected and the incidence may be as high as twelve per cent. Crossbreds and British breeds seem to be as susceptible as merinos. Bred ewes are the ones commonly seen to be

*(1940) Underwood, E. J., Shier, F. L., and Beck, A. B.—J. Dept. Agric., West Aust. 17 : 388.

† In some countries prolapse of the vagina is fairly commonly seen, just prior to lambing, in ewes which are very fat, particularly those carrying twins. This condition is ascribed to excessive straining in unsuccessful attempts to pass urine; it is postulated that ewes by reason of sluggishness resulting from lack of exercise, high bodily condition and late pregnancy delay urination until a number of factors, including the pressure of the heavy womb on the bladder, render the act difficult or impracticable.

This type of prolapse has been seen only rarely in this State and few animals have been affected in the flocks concerned.

In the early stages the prolapse appears to consist of the everted anterior vaginal wall and cervix enclosing a proportion of the inverting body and horns of the uterus. In cases where the prolapse has been presenting for two or three days the caudal third of one or both uterine horns has been intussuscepted into the inverting body of the uterus. Later the cervical canal dilates, becomes patent and the condition progresses to a complete inversion of the uterus. In advanced cases even fallopian tubes and ovaries may be extra-pelvic. The broad ligaments are, of course, greatly stretched.

affected, but dry ewes, maiden ewes, and even weaners and lambs are not insusceptible; in one instance 20 of 250 maiden ewes were reported to have been affected, whereas few cases were encountered in bred ewes running under similar conditions on the same property. It seems obvious therefore, that the trouble cannot be ascribed to causes resulting from breeding.

The condition occurs, generally, during the months of August to November. It may appear as early as July. The occurrence as a rule is checked when pastures dry off although occasional cases are seen during the late summer and autumn months. It appears possible that many of these cases occurring during the dry feed period may be recurrences of previous trouble. Spontaneous recoveries are known to occur in the earlier stages, up to a week after signs are first noted, particularly following change of pasture or temporary starvation as in yarding, etc. Although there is little definite information on the point it appears unlikely that many of these recoveries are permanent, and it is known that the prolapse may recur, within a few months, in these cases.

In affected ewes the first sign noted, generally, is the protrusion of an inflamed red knobby swelling. Careful observation may reveal an earlier stage when the ewe strains and bleats in a lying position as though attempting to lamb. After the prolapse is obvious externally the condition gets progressively worse until, within two or three weeks, the uterus is completely or almost completely turned inside out (inverted). It ultimately projects from the body as a swollen tube up to ten inches long and three inches in diameter. The exposed surface, actually the inner lining membrane of the organ, is at first highly inflamed and red but later, due to injury and bacterial contamination, becomes yellow, stinking and necrotic (dead); the initial swelling and enlargement of the inverted organ subsides.

Affected sheep are usually slaughtered when found. If not they may survive for months or die from infection, toxaemia, or from the effects of rupture of the prolapsed womb.

Apart from the changes in the womb and its supporting structures no constant abnormalities are found in the carcases of sheep affected with various degrees of prolapse.

Attempts at replacement of the prolapsed organ and its fixation in position by various methods adopted by sheep owners are not generally successful. This is not surprising. The uterus is normally held in position by supporting structures (ligaments). These are very greatly stretched in cases of prolapse so that even if the organ is satisfactorily replaced there is no normal mechanism to retain it in its proper position.

We have referred in the introduction to the relationship between prolific and dominant subterranean clover pastures and the occurrence of inversion of the uterus. There is additional evidence suggesting that subclover is in some way responsible for the condition. It was reported from several properties that removal from subclover pastures prevented any further incidence in affected flocks, although fresh cases occurred if ewes once more had access to green subclover paddocks. Occasional spontaneous cures have followed removal from clover pastures.

The prolapse is not of bacterial origin, and other lines of investigation have given no lead as to the possible cause.

The relationship of subterranean clover to the occurrence of prolapse is being studied further.

3.—THE CONTROL OF DYSTOKIA AND INVERSION OF THE UTERUS.

As the real cause of either condition is unknown no definite recommendations can be made for the control of dystokia and inversion of the uterus but some palliative measures, based on present information, are suggested for trial pending the results of investigations now in progress.

It has been stressed that both conditions occur, as problems, only where early subterranean clover dominates the pastures. It seems reasonable therefore to consider that the provision of a more mixed diet would considerably lessen the seriousness of both problems, although we have yet to prove this. An attempt should be made to balance the clover with other herbage. For this purpose the "scratching in" of oats on clover paddocks would appear to be an *immediate* practical remedy.

The feeding of dry cereal hay during the green feed period is also worthy of consideration.

The appropriate use of unimproved pastures, particularly to prevent the occurrence of further cases of inversion of the uterus in affected flocks, may be practicable in some instances.

Experience in the past three years appears to indicate that serious occurrences of dystokia and inversion of the uterus are directly related to favourable seasonal conditions resulting in a long green feed period. Until we are able to compare the incidence in subsequent "normal years" it is not safe to assume that the problems are seasonal ones.

Because of the evidence relating the recent occurrences of dystokia to exceptionally favourable seasonal conditions, it was suggested that merino breeding ewes be maintained in lower condition until within two months of lambing (when a higher plane of nutrition is required to prevent the possible occurrence of pregnancy toxaemia). This measure appeared to have given a degree of success on some properties in 1943.

Data already obtained for the 1944 lambing, however, clearly indicates that a lower plane of nutrition does not necessarily prevent the occurrence of dystokia and that other factors not yet understood have an important bearing on its occurrence.

It is evident, also, that the improved and highly productive pastures in the affected areas are more suitable for raising crossbred sheep and cattle than for the maintenance of merino flocks. Such a change in husbandry would eliminate the dystokia problem. Other measures are necessary to control inversion of the uterus, which contrary to dystokia is not a problem confined to the merino breed.

4.—SUMMARY.

1. A description is given of two conditions which occur as serious problems throughout the areas where early subterranean clover dominates the pastures. They are dystokia in merino ewes and inversion of the uterus affecting ewes of other breeds also. These names are used, in a restricted sense, to describe two characteristic conditions which do not seem to have been reported elsewhere. The dystokia is characterised by the fact that ewes give little or no evidence of the normal signs of lambing and that the full term foetus (unborn lamb) is dead. The inversion of the uterus is unusual in that it occurs typically several months after the breeding season and that unbred animals are susceptible.

2. Both problems have assumed serious economic importance only during the past three years when unusually favourable seasonal conditions resulted in luxuriant pasture growth and an early or long green feed period. It is too soon yet to assume, however, that they are merely seasonal problems.

3. Investigations have, so far, failed to determine the actual cause of either condition. Neither is due to an infectious agent. Present evidence indicates that both are of nutritional origin and in some way related to the dominance of early subterranean clover in the pastures.

4. No recommendations for control can be made, with confidence, pending the results of investigations, now in progress, which are designed to test the truth of the propositions advanced and to determine causes. In the meantime certain changes in management and husbandry, which on present information have a reasonable prospect of success, are suggested for trial.

Honey Resources of South-Western Australia.

L. BLAIR, Government Apiculturist.

Owing to the very dry conditions prevailing in Western Australia generally during the summer of 1944, when practically no rain relieved the position for over six months, the apiarists experienced a very lean time, and the production of honey and beeswax was greatly reduced, supplies proving inadequate to meet military or civilian requirements. This position was aggravated by the white gum (*E. Redunca*) or summer white gum, which produces one of our best honeys and provides the largest source of supply, failing to flower this season. After a flowering period of two and sometimes three and four consecutive seasons, this tree has a two-year break when young buds are developing. Added to this, the winter white gum, which starts flowering in March, was devastated by unusually severe bush fires, which reduced the areas by practically two-thirds.

The supply position became so acute that the possibility of moving hives to other parts of the country was examined, and with this in view, arrangements were made for me to make an inspection of other sources of nectar supply which might possibly be drawn upon to relieve the situation. A trip was arranged, and the route taken was from Perth through the south-western portion of the State and as far east as Esperance.

I found that the red gum or marri gave little promise. From 25 per cent. to 75 per cent. of buds failed to mature because of the dry conditions and the majority of the buds dried up and dropped off, thus terminating the possibility of any honey from this source.

Many conflicting reports had been received about the karri as a source of supply of nectar, but on investigation it was found that this tree would not bloom until after the winter rains had commenced. Owing to the cold and wet conditions in the karri-growing districts in the winter months, beekeepers were advised not to transport bees to the karri until the spring (October, November). The karri should then flower right through until April or May, 1945, providing the dry summer this year does not adversely affect the storage of starch which is transformed into sugar, and is used by the tree either in the form of nectar to the flowers or conversion into new growth to the tree and foliage.

A great number of trees had shed a considerable quantity of buds, but this is often the case just prior to a flowering period. After leaving the karri areas (Manjimup and Pemberton) towards Denmark and Albany the condition of the karri buds did not seem so numerous or well advanced.

The districts generally have all suffered from bush fires, the bees throughout having a lean period. After leaving Mt. Barker, the summer white gum areas were encountered, which gave promise of good seasons to come, as about 50 per cent. to 75 per cent. of the trees were carrying nice clusters of buds that should commence flowering next November-December and continue until February, 1945. At about this time red gum should begin and provide the bees with a nice surplus and sufficient stores to see them safely through the winter of 1945. The following year should also prove a good one in the white gum or wandoo areas as the trees are carrying two sets of buds; one will flower next summer and the second set the summer following (1945-46).

From Tambellup we travelled east through Ongerup and Needilup to Ravensthorpe and Hopetoun districts. Shortly after leaving Tambellup, we encountered many species of mallee and there were flowers in abundance. Some varieties had finished flowering, and had set fruits; others were in full bloom and others still in bud. A number were full of nectar, with ample pollen supplies, but very few bees there to take advantage of it. All indications pointed to an ample flow in these districts extending back over many months.

We travelled 150 miles east in this class of country, and were never without sight of some species of flowers on the sand plain country, either mallee, yate (*E. Cornuta*) or gimlet (*E. Salubris*). In the belts of salmon gum (*E. Salmonophloia*) and yate, parrakeets—those expert nectar prospectors—were in great numbers on the salmon gums which at that period had nearly finished flowering.

Between Ravensthorpe, Kundip and Hopetoun one enterprising apiarist had a great number of hives, and they were doing very well, the bees taking full advantage of nature's bounty. In every direction we went in these districts, the same country was encountered, and the profusion of flowers was a constant source of delight from an apiarist's point of view, and the possibilities of this area opened up a wonderful vision for the future. This type of country extends for over 300 miles east of Albany and should be able to carry a large number of commercial apiarists in the post-war period, when the manpower, petrol and tyre position should ease up somewhat.

It would not be possible to judge the number of hives this territory would carry from a short trip or period spent on a tour of inspection, but by all indications it appeared that there is unlimited opportunity for the industry here. On a conservative estimate, hundreds of tons of honey and thousands of pounds of beeswax went to waste and were lost to Western Australian apiarists and the war effort.

The greater portion of the country traversed was very dry and water would be a factor that may limit, to a certain degree, full exploitation. However, soaks, springs, dams and rivers in this territory could be located and taken advantage of by the migratory apiarists. I am of the opinion that it would not be suitable for clearing as it appeared that soil erosion would take place very easily, as I noticed that from one cleared portion near a river beside which we camped a continual dust cloud arose, irrespective of the direction of the wind.

It is hoped that these brief notes, representing my impressions after a quick glance through many miles of virgin territory, may indicate to apiarists and intending apiarists the immense possibilities awaiting exploitation in these areas.

Some Poultry Problems of the Householder.

G. D. Shaw, Poultry Adviser.

In these days of rural production campaigns, together with the shortage of eggs, the householder has responded by increasing the holding of poultry stock by the purchasing of a few chickens or grown fowls in order to obtain a home source of supply of eggs and meat.

This procedure has brought forward many problems both to the householder and to the Department and this short article is an endeavour to clear up many points of misunderstanding and ignorance of the matters applying to the rearing and management of poultry on small holdings.

From the beginning good housing is essential. This does not mean that the house should be expensive. It does mean, however, that the house should be dry, free from rain and have cement floors. A house six (6) feet wide and seven (7) feet deep, and high enough for the manager to enter without hitting his or her head will hold twelve fowls with comfort.

Twelve fowls, housed correctly, and fed properly, will keep the average householder in eggs throughout the year. Yard space is not so important. Small yards attached to the house will allow of some freedom to the birds. They will, however, need to be kept clean.

SHEDDING.

It is recommended, however, that the shed should be so self-contained that there is no need for a yard. The above shed will fulfil the requirements of house, feed room and recreation room. Perches, laying boxes, scratching litter, water and grit boxes are all inside the house. A neat house embodying the above conditions will not be expensive and when installed will be an asset to the property. A poor shed and a still poorer yard space will be a detriment. It will tend to cause smells and be a nuisance to the householder and the neighbours.

PERCHES.

For twelve fowls one perch only is required at the back of the shed. See that the perch is twelve inches from the back of the shed. Use three by one and a half (3 x 1½) inch material on the flat, and rest the perch on bearers attached to the side of the shed.

Two feet from the back and on the floor place a piece of six by one (6 x 1) timber extending across the shed. This divides the floor into two parts; two feet under the perches which is used to separate the droppings and the remainder of the floor which is covered with lawn cuttings and other similar litter to a depth of four to six inches. This portion of the floor is then used by the fowls for scratching litter and for recreation.

Two nest boxes attached to the front wall provide the laying requirements. The water is also on a platform attached to the front wall. Both nests and water are three feet from the floor. A small box for grit, a door in front and the shed is self contained. The nests and water trough can be so placed that they can be attended from the outside. So much for the shed. The design is immaterial but the above are the principles.

STOCK.

There is only one reliable way of obtaining stock. There are, however, many ways of purchasing the layers. Firstly, one can purchase so called laying fowls from doubtful sources. Secondly, one can purchase laying fowls from well known sources and, thirdly, one can purchase day old chickens.

Do not purchase stock from unknown or doubtful sources. Too many give orders to the greengrocer or the woodcarter. Too many purchase from dealers in poultry. Too many buy at the auction markets. These sources in most cases result in introducing vermin and sickness apart from the fact that the birds so purchased are in most cases nothing more than the rejects from commercial poultry farms.

When one considers the purchase of laying stock from well known sources such as commercial farms of repute and from those who are reducing stock for legitimate reasons, one will obtain reasonably good fowls, but the price will be high because the seller will not sell good fowls for a cheap price. One may, however, obtain all one desires because in many cases a reasonably high price may not be a hardship.

The third source is the most satisfactory. The purchase of day-old sexed chickens from a reputable hatchery assures the buyer of good reliable stock which has not been in contact with disease and vermin. This assurance is worth many pounds in value. It will compensate for the loss of time in waiting for the chickens to grow into laying pullets.

If the second course—that of buying grown fowls from a reliable source—is followed, the holder will not have the trouble of rearing, and the fowls, if of the right age for laying, will begin giving eggs at the earliest. The purchaser should, however, buy pullets on the point of laying. On the other hand, if these are not available or the price too high, the purchaser can buy first year hens in the moult and feed them for a few months (generally three) until they begin to pass into the second laying season.

If one purchases the day old chicken or the started chicken one has the satisfaction of rearing the stock as one desires, and the attention thus displayed will be an added source of satisfaction when they reach the laying stage. There are certain problems but they are easily overcome with management.

REARING THE CHICKEN.

Chickens first out of the brooder must have heat and must continue to have heat until they leave the heat of their own accord. They are the best judges of when to discard their baby ways. They know when to leave the heat and shift to the perches.

There are three ways of supplying the heat. In order of merit:—

Firstly with the broody hen.
Secondly with the use of a heated brooder.
Thirdly with the cold brooder.

With the broody hen, this method is the best for the householder, but one cannot always obtain a broody hen when desired. All endeavours should be made to obtain a hen from some poultry farmer nearby. Place the hen in a dark corner

of the shed and cover her with a box of some sort. Give her water and food and place two ordinary eggs under her. Fresh eggs from the cupboard will do. When the chickens arrive, they are placed under the hen at *night-time* and the eggs taken away and used for the house. The hen will mother those chickens at once and the first worry is over. The hen and the chickens are then treated as you would for any other batch of chickens (see below).

The heated brooder is a piece of plant common on every poultry farm. The designs are many and the methods of applying heat are varied. For the householder one can recommend one of the smaller heated brooders of commercial manufacture. These, however, are hard to obtain and resort may have to be made to the home-made brooder heated with either a hurricane lamp or hot brick.

Small brooders are satisfactory when one is dealing with a limited number of chickens and one can extend the use of small brooders to meet the demand of many hundreds. One advantage of small units is that the chicks are under closer observation than when they are in large numbers. The satisfactory unit is up to 75 to 80 chicks. These can be contained under the standard 100-chick unit. When purchasing a brooder, estimate the capacity to be 75 per cent. of that advertised. One can place 100 day-old chicks under a 100 brooder, but owing to the quick growth of the chicks, by the time they are three weeks old the brooder is overcrowded.

In all brooders there is a hover and a nursery, although in many cases the nursery is eliminated and the shed in which the brooder is placed is divided into runs which act as a nursery for the young chicks. If the brooders are to be placed outside it is advisable to have the hover and the nursery connected in one unit. Brooders must be well heated, and there should be a perfect union of the heat, top, side, and bottom. Such fusion of heat will be obtained inside a shed having good ventilation, and covered with litter on the floors. Hot air brooders are operated on the principle that the air is heated by an oil lamp, and is then directed upwards and into the hover on top of the young chicks. It is there diffused and in cooling falls down on the backs of the chickens and so keeps them comfortably warm. No matter what may be the outside conditions, an efficient brooder will be able to maintain an even heat inside

Temperature of Brooders.

The proper warmth is of the utmost importance. It is recommended that the temperature should be about 95 degrees Fahrenheit, but this may have to be altered to meet the changing atmospheric conditions. It is never advisable to rely on the thermometer. The attitude of the chickens under the brooder is the best guide. The chickens themselves will, by crowding or otherwise, inform the attendant whether the heat is sufficient or not.

Make the chickens spread out. If there is any tendency to crowding it should be evident that the heat is too low, and, no matter what the thermometer reads, it is essential that more heat should be applied so that the chickens spread away from the source of heat. A common symptom of insufficient heat is the attraction to the chicks of the light of the lamp. Many owners will mistake this for curiosity, but the real cause will be that the chickens are cold and are crowding the lamp.

If the hot brooder is home made (using a kerosene lamp or the hot brick regularly replaced) the manager has an added responsibility, for the lamp will probably not give quite the 95° F. of heat and the hot brick will have to be replaced many times a day and also late in the evening.

Plenty of bags round the brooder will help to retain the heat from the lamp or brick.

When the chickens arrive, the brooders should be already heated and the chickens placed under without undue delay. They should spread out and if the temperature is correct they will NOT crowd round the heat.

The cold brooder is nothing more or less than a box inside of which is a tray which will cover the chickens. The tray is placed about five inches above the floor of the box and covered on the underside with bags and flannel strips hanging down so as to touch the backs of the chickens. To retain the heat, bags are placed over the tray in sufficient numbers to keep the heat inside where the chickens rest. The floor should have plenty of covering with sand and chaff. There is an opening in the box so that the chickens can proceed outside into a small yard. With this type of brooding equipment the manager must see that at no time are the chickens subjected to cold winds nor showers of rain which will wet them. The animal heat of the chicken itself warms up the breeder; an analogy may be drawn with a room full of people. The brooder actually conserves the heat given off by the chickens inside, and should they go inside when the brooder is cold it takes time for them to warm up the brooder and the time so taken may be too long and the chickens obtain a chill.

Many hundreds of chickens are reared with cold brooders, but nevertheless, they are successful only when the manager pays great attention to the smallest details.

Feeding.

The feeding of day old chickens is most important and no better advice can be given than to obtain some recognised chicken mash and feed according to instructions. If they are running with a broody hen they can still all be fed with the chick mash.

Water.

Water should be in front of them all the time, but should the water run out at any time they must not be given further supplies until they have had a good feed. No water on an empty stomach.

Shell Grit and Grit.

Plenty of shell grit and stone grit should be in front of them at all times.

Perching.

At eight weeks they will desire to perch and at this stage there is a tendency for the young pullets (as they are now called) to perch too early. Remember that the nights are cold and while the evening may be quite warm the night gets colder as the early morning arrives. They should therefore not be allowed to perch before they are feathered.

The perches should be well spread apart. They should be so far apart that when the chickens (and for that matter all stock) are facing one another there is at least twelve inches between their heads. No matter how crowded they are side by side there is no danger of overcrowding. It is when they face each other that danger exists. They cannot survive if they are breathing each other's breath.

At three months, they should be vaccinated. The operation is simple and although the minimum doses are sold in bottles of 50 for 5 - it pays to waste the balance even if only twelve birds are on the holding. Two or more householders could combine for the vaccination. Vaccination against fowl pox will save endless trouble later in the year, but remember that vaccination is not the end of all trouble. If the management is at fault the birds will, through weakness due to mismanagement, contract other and worse troubles.

CHICK AILMENTS.

Pullorum disease. Noticed at about three days old and onwards. Pasty behind, listness, and death. Chicks must be examined by a pathologist before diagnosis can be considered satisfactory. Do not confuse this with a common chill taken during the first day under the brooder or slightly later. Only an examination will disclose the trouble. Management of brooders will assist to keep cold troubles in check.

Toe Picking.

This is a vice and the owner should watch the chickens at feeding time and the first chick noticed that does not feed but goes round pulling the toes of those feeding should be killed off. Do not confuse with the innocent curiosity of all chickens of having a pick at any bright object such as the toes of other chicks. The "tugging" effect is the characteristic to watch; if allowed to get a hold the vice will spread throughout the flock.

Vent Picking.

This is another vice. Continued watching of the chickens will find the culprit. Kill it. The injured chicken should be removed and not replaced until the wound is cured. Any blood will cause the others to adopt the vice.

Feather Eating.

With young stock this generally indicates a shortage of protein. The remedy is obvious.

Worms.

Worms attack chickens and fowls and are responsible for many deaths.

Symptoms: Wasting away, loss of appetite, ruffled plumage, and mustard-coloured droppings sometimes tinged with blood. Always be on the lookout for worms. These are of many species and they should be treated with the proprietary mediums or by the use of Black Leaf 40, as follows:—

Use ½ oz. Black Leaf 40 (one tablespoonful) to each 250 grown fowls. This is equal to one teaspoonful to every 60 fowls.

Mix the Black Leaf 40 with the water or milk used for making the morning mash. Treat for four days in succession.

Some poultry farmers are following the above treatament with one per cent. tobacco dust in the mash daily for three or four weeks.

LAYING.

As they grow to maturity it will be found that the birds show different characteristics. Some are larger than others. Some have small snake-like heads. Others are showing large bodies. Others are weeds. This cannot be helped. The hatchery has given a good chick but the management or the throwback has caused the difference noticed at maturity.

The birds should be encouraged to go to the nests. Do not let them lay away from the house. If they are always confined to the house the trouble ends. They cannot fly over the fence and therefore are no trouble to the neighbours. When they drop the first egg they should be fed for laying. Again the mash as sold will meet the requirements but they must have all they can eat. As the ration is not sufficient the feed must be augmented with more gristed wheat mixed in the mash. Feed mash in the morning (wet or dry it matters little), greens at lunch and wheat at evening followed again by greens. A wet mash is one slightly damped with water to a crumbly state, i.e., one that will just hold together. The amount of greens required is about equivalent in bulk to the dry matter given to them and this also applies to the greens after the wheat. Give the same greens in bulk measurements as the amount of wheat given. Allow about one handful of mash for the morning and one handful of wheat at evening. The common measurement is one golden syrup tin of wet mash for five birds in the morning and one tin of wheat for 15 at evening feed. When given plenty of food the birds will lay many eggs and so help the larder, but by this time we are near the annual moulting season; the season when the birds which have performed heavy laying for twelve months will decide to drop their feathers and grow new ones. The pullets have begun to lay and any setback at this time will cause them to moult (cast feathers and grow new ones). When they moult they cease laying.

The causes of pullets moulting are many. If they are born outside the spring months they will go into a moult; poor feeding will cause a moult; contracting fowl pox will cause a moult; contracting bronchitis and other similar troubles will cause a moult. Vermin also will cause a moult. All these cause a stoppage of laying.

The fowl pox danger has been eliminated by the vaccination of the pullets during the time they were between three and four months old and this disease will not trouble you. Poor feeding is a prevalent cause of moulting but by following the instruction on the mash bag the birds should respond. Vermin should be overcome by good management which will keep the fowls in lay.

MOULTING.

The mention of moult needs an explanation. Moulting is an annual function of poultry. All birds will shed their coat of feathers every year during the months of January to June; some start in early January and others later, say from April to June.

Early moulters are not as valuable as late moulters. This moult is a reconditioning of the birds' feathering and when moulting they seldom produce eggs. One could say that the moulting bird does not lay; actually the percentage of laying during the moult is about 4 per cent. As the feathers are very high in nitrogen the birds must be fed plenty of protein when they are growing feathers, therefore it is necessary to keep the layers' mash before them. One cannot get eggs and feathers, and until the feathers are fully grown eggs will not be found. The moult is generally finished by the end of July and according to the method of feeding during the moult the sooner will eggs be received after the moult. Because the birds will moult during the autumn and winter it is always desirable to have young pullets coming into the lay in the early autumn and so assure a supply of eggs during this period. Therefore purchase some chickens every year and so keep continuity of supply.

Remember, however, that the continuity can easily be broken if the pullets also go into a moult because of sickness and/or poor management.

VERMIN.

Tick, red mite, scaly leg, feather lice and depluming mite can be kept in check by the application of the following oil preparation:—

10 gallons of creosote
10 gallons of deiselene
2 gallons of liquid sheep dip

thoroughly mixed together and swabbed into joints and cracks. Smaller quantities, however, can be made in proportion.

Note: At present permits are required for this mixture or for ingredients to make the mixture and they are obtained on application to this Department. You must state, however, the size of the building being treated.

Tick are flat round vermin, similar in shape to the ordinary bug. They are the worst trouble we have and cause many deaths. They must be kept out of the properties.

To eradicate, you must saturate all cracks and joints in the woodwork of your fowl sheds, taking care to prize open the joints with a hammer and chisel and seeing that the oils pass through the joints from one side to the other.

Having completed the treating of the shed you must work away from the shed by treating all other infested timber, iron, and possible rubbish.

Red mite and other blood-sucking vermin which inhabit the fowl sheds can cause trouble by lowering the condition of the birds and can cause death.

Scaly leg is caused by a mite, and the symptoms are a scaly swelling on the feet and shanks of the birds; if allowed to get bad it causes lameness and poor production results.

Feather lice are similar in shape and colour to the lice which prey upon humans. They cause loss of condition, skin diseases, and attacks may be so severe as to cause death.

These four vermin can be kept in check and eliminated by applying the mixture above. If, however, the birds are affected before the treatment is applied, the scaly leg can be assisted by rubbing the legs with a rag dipped in kerosene or even by dipping the leg in kerosene for about two (2) seconds and then wiping clean. The scale will fall off in about four weeks. Feather lice can be cleaned out by rubbing into the feathers some insectibane or similar preparation.

Depluming Mite.—Depluming mites are not seen by the naked eye but the results are easily discerned. The skin is first of all shiny and then takes on a sunburnt colour. The feathers are missing from the portions affected by the mite. This "sunburnt" effect is typical of depluming mite. Rub the affected parts with some vegetable or animal oils or fats.

COMMON AILMENTS.

Fowl Pox.—First symptoms of fowl pox are generally "winking" of the eye when a fierce light is played thereon. Remember the difference between "winking" and "blinking." The following series of symptoms may develop but not necessarily in rotation or all together. They may show up singly, they may show two or more together:—Sweaty eye, running nose, scabby nodules on comb and lobe, nodules above and below eye tending to run into one another and so close the eye; cheesy formation in the corner of the eye, cheesy formation on and under the tongue, cheesy formation clogging the windpipe.

Treatment.

Lift scabs and cheesy material from affected parts and rub in a zinc ointment made as follows.—

Zinc oxide	one part by bulk
Lard	one part by bulk
Sulphur	one part by bulk

Mix thoroughly. Dilute down to the consistency of separated cream with either olive or salad oils. The sulphur can be eliminated if difficult to obtain. Syringe the nose with peroxide of hydrogen, and place one drop of argyrol in each affected eye. Should the eyes be stuck together, clear away and place ointment between the lids to stop premature adhesions. Next year vaccinate. Vaccination takes place on the thigh of the bird with a prepared vaccine sold by any poultry requisite store.

The operation is performed when the birds are between the ages of 10 and 16 weeks. Before or after this period vaccination is liable to cause trouble. The operation is simple and effective, and instructions are contained in each package. Nine days after operating, examine the birds' legs for "takes"—these are evident by the formation of a scab at the point of the operation. If 80% of the birds "take," your flock can be considered reasonably immune.

Chicks must not be allowed to crowd when under the brooder. As they grow up they must not be allowed to crowd into corners. At the time of perching they must be made to perch and NOT rest on the floor. The perches for both young pullets and hens must be so far apart that when the birds sit facing one another there is at least 12*in. between the heads.* Nothing less than 12in. is satisfactory. When the perches rest on bearers birds must not be allowed to perch on the bearers, for they can then have heads close to the one sitting on the perch. The birds can sit side by side on a perch and the situation is not dangerous.

Remember that vaccination without good management is a greater danger than no vaccination with good management, and remember also that the lack of vitamins in the ration through shortage of green feed will give symptoms which to the layman are similar to fowl pox. Therefore see that your flock receives ample green feed, at least the same in BULK as you feed other ingredients.

Vitamin A Deficiency.

The symptoms may be similar to some degrees of pox. For instance the eyes will run and seal over and the throat will show in some cases many pin points of white coloured pimples. Plenty of green feed will prevent this complaint, but if the diet has been short of green feed do not confuse the pox with vitamin deficiency.

Correct the shortage of green food by giving more feed or give one pint of cod-liver oil or similar oils to every hundred pounds (dry weight) of mash. Householders should not be short of green feed, therefore it is likely the trouble is fowl pox.

Bronchitis.

Another hardy annual can be assumed with a degree of certainty when the tips of the comb show a bluish tinge. Watch the breathing. No mouth should be open when breathing. The nose should be clean, a running nose usually denotes

a cold and therefore suspect also bronchial infection. Running nose, running eye and an open mouth when breathing are symptoms of trouble which are detected easily.

Down Behind.

This is another cause of worry to the householder, the name aptly describing the complaint. The abdomen is heavy and sometimes touches the ground. The bird waddles rather than walks. It may be:—

(1) Filled with water.

(2) A hard lump easily moved inside the skin.

(3) Hard lump not movable.

(1) No cure. Kill and bury. Probably caused through a rupture.

(2) A foreign growth or a cyst. Kill and burn or bury deep.

(3) Most likely congealed eggs held up inside. Kill and bury.

Leg Weakness.

This is a common fault with every disease and is understood to be present when a bird is sick. The only time it is valuable in diagnosis is when the weakness takes on an unnatural form such as the legs spread out sideways or the joints swollen and the bird is otherwise in good health.

Soft Shells and Thin Shelled Eggs.

Soft eggs from a pullet when laid from the perch at night-time is nothing to worry about; the pullet probably laid a shelled egg in the nest in the day time. She is ripening eggs so fast that they are not being held long enough to shell. This will disappear when she settles down to steady laying.

Thin shelled eggs on the other hand denote that while the birds have plenty of shell grit in front of them and even have lime in the mash, they are not assimilating the shell forming material and therefore the shells are poor. The birds need a tonic and the best tonic is as follows:—

Dissolve 4 ozs. ferri perchlor. in two cups of water. Use the resultant mixture (perchloride of iron) at the rate of one quarter drop per bird.

The dose is say, on Monday, mix one teaspoonful of the perchloride of iron to each 250 birds, in the liquid that mixes the mash.

On Thursday, mix one teaspoonful of tincture of iodine to each 60 birds in the liquid which mixes the mash.

Repeat on the second Monday with the perchloride of iron.

Repeat on the second Thursday with the tincture of iodine.

Two applications of each is sufficient.

This tonic should be given the birds in the months of September, November, February.

PREVENT THE INTRODUCTION OF DISEASE.

When any fowl is bought, it should be isolated for at least three weeks before it is allowed to mingle with the flock. Many a new bird has brought trouble to the new owner, owing to his not keeping it apart from the rest. First see that the bird is clean about the head, comb and wattles, and free of sores and warts.

Open the mouth and look at the throat and under the tongue; take note of the hen's breath—it should not give off any offensive odour. Examine the eyes. They must be dry with no bubbles in the corners. The nose must be clean and free for breathing purposes. The earlobes must be clean and free from warts, etc. Feathering should be tight and there should be no bare patches. Bare patches denote parasites. The crop should be empty after a journey. A full crop is a bad sign. The breast should be straight and free from scales. Vent feathering should be dry and free from lice eggs. A healthy back region is fluffy and clean. Legs must be clean—look for scaly legs.

The above are a few of the troubles of the beginner in poultry farming. A constant lookout for any ailing bird will save an enormous amount of trouble and distress.

On noticing an ailing bird, immediately catch and separate it from the rest of the flock—it is a source of danger. Never kill a fowl without opening it to confirm your opinion of the cause of death. The practice of burying or otherwise disposing of dead birds without knowing the disease from which they died, gets one nowhere and is often the cause of having a later epidemic. If one were to post-mortem each dead fowl and ascertain the cause of death, one could then be prepared for trouble should one find a death due to infectious or contagious disease.

To Post Mortem.—Place the bird to be opened on a table, breast upwards. Cut off both legs and remove the feathers from the breast bone area. Insert the operating knife between the last rib and the breast bone and cut towards the neck. Do this both sides of the bird. Pressure on the breast bone forcing it upwards and backwards will break the bone near the neck and expose the whole of the inside of the bird. Care must be taken to ensure that no damage is done by cutting the internal organs while preparing the carcase for external exposure. Circle the vent with the operating instrument, taking extreme care not to damage the intestines, carefully untangle the intestines and withdraw carefully until the whole is laid out clearly beside the bird.

On examining the intestines upwards from the vent, one will find two blind branches to the intestines running in a downward direction. These blind branches are called the "caea."

Examine the liver and note its colour. It should be of a blood-red colour, not yellow. See if it is large or small. Note its texture when cut. Look to the condition and size of the heart. See that the lungs are salmon pink, and neither congealed with dark blood nor hard to the touch.

Intestines.—Open up the intestines and look for any inflammation or blood coloured portions and worms.

Gizzard.—Open this and look for any inflammation therein. Note the contents of the crop—clean or sour, food and water.

General Conditions.—Note whether the bird is fat or in poor condition. It has a great bearing on the resistance to disease. Look for lice and other parasites. Note the general colour of the internal membranes. They should look healthy and not discoloured.

By way of comparison, when a bird is killed for eating, examine its organs with a view to knowing just what a healthy bird is like. A good idea will then be gained of what is abnormal when examining a fowl which has died from an unknown cause, and, lastly, when an examination has been made and advice is needed, a more intelligent description of the morbid symptoms can be given.

Muresk Agricultural College Pig Feeding Trial III.

M. CULLITY, Superintendent of Dairying, C. R. DIXON, Piggery Instructor.

The trial was arranged in order to test the possibility of replacing part of the 10 per cent. meatmeal usually recommended as a mixture with grain for feeding pigs by a protein-rich food of vegetable origin, linseed meal being selected for the purpose. A comparison of a linseed meal-grain-meatmeal mixture was made with three different mixtures of grain and meatmeal. The grain mixture was comprised of equal parts of crushed wheat and crushed barley.

Four groups were selected, each containing four pigs from four litters, there being a representative of each litter in each group. They were fed as follows:—

Group 1.—Grain, 90 parts; meatmeal, 10 parts.
Group 2.—Grain, 87 parts; meatmeal, 7 parts; linseed meal, 6 parts.
Group 3.—Grain, 87 parts; meatmeal, 7 parts.
Group 4.—Grain, 95 parts; meatmeal, 5 parts.

Analysis of the feeding stuffs showed the following percentages of protein on a water free basis:—

Crushed grain	12.32% protein.
Linseed meal	34.88% „
Meatmeal	51.4% „

The percentage of protein fed to each group was therefore:—

Group 1	16.2%
Group 2	16.4%
Group 3	15.2%
Group 4	14.2%

Green feed was available to all pigs up to the commencement of the trial: di-calcic lick formed 2 per cent. of all rations and water was always available.

The quantities fed to each group were as follow:—

Week ending.	Mixture lb.	
28th September	2 ..	All four groups.
5th October	2 ..	„
12th October	2¼ ..	„
19th October	2½ ..	„
26th October	2¾ ..	„
2nd November	3 ..	„
9th November	3¼ ..	„
16th November	3½ ..	„
23rd November	3¾ ..	„
30th November	4 ..	„
7th December	4¼ ..	„
14th December	4½ ..	„
21st December	4¾ ..	„

Week ending.	Mixture lb. Group 1 and 2.	Group 3 and 4.
28th December	5¼ lb.	4¾ lb.
4th January	5½ lb.	5 lb.
11th January	6 lb.	5½ lb.

The trial was continued until the fastest growing group approximated 180 lb. live weight. The pigs were then despatched to a bacon factory for slaughter and curing.

It will be noted that although the fastest growth occurred in Group 1, Group 2—which received linseed-meal replacing 30 per cent. of the meatmeal in Group 1—made only slightly less rapid gains. The group receiving 8 per cent. meatmeal made good growth, although the gains were not as great as Group 2 which had the same proportion of grain to meatmeal with the addition of linseed meal. Group 4 which received only 5 per cent. meatmeal made the slowest growth.

The principal details relating to rate of growth, food, consumption, etc., are summarised in Table 1.

TABLE 1.

	Group 1.	Group 2.	Group 3.	Group 4.
	lb.	lb.	lb.	lb.
Average weight at commencement of trial ...	49·75	48·75	47·50	49·25
Average weight as end of trial	182·5	179·7	169·7	166·2
Average gain per pig	132·8	131·0	122·2	117·0
Amount crushed grain consumed per pig ...	373·3	360·9	371·75	384·25
Amount meatmeal consumed per pig ...	41·4	29·0	32·5	20·0
Amount linseed meal consumed per pig ...	...	24·8	...	...
Weight of food per pound of live weight increase	3·1	3·2	3·3	3·4
	s. d.	s. d.	s. d.	s. d.
Total cost of feed per pig	25 11	26 9½	24 8½	23 10
	d.	d.	d.	d.
Average cost per pound of live weight increase	2·34	2·45	2·43	2·45

Group 1, which made the most rapid growth also was the most efficient for converting food into meat, using 3.1 lb. of food for each 1 lb. live weight increase. It will be noted that this figure is the same as that for Group 1 in the trial reported in this Journal in March, 1943, when a greater proportion of meatmeal was fed. This suggests that there may not be need at any time to incorporate more than 10 per cent. of meatmeal in the ration.

The amount of feed needed for each pound of live weight increase was slightly higher in Groups 3 and 4 than in Groups 1 and 2. However, during a period of shortage of meatmeal, satisfactory growth can be achieved by using smaller amounts of this supplement than are recommended for most rapid growth. Where the proportion of meatmeal is reduced, linseed meal can be used to augment the amount of protein.

An analysis of the profit over the cost of feeding is shown in Table 2. The largest profit was obtained where the standard ration (10 per cent. meatmeal) was used. The cost of feeding Group 2 was slightly higher and the margin of profit 5s. 5d. per pig lower than for Group 1.

TABLE 2.

PROFIT OVER COST OF FEED.

Group No.	Value of Pigs.	Cost of Feed.	Margin—value over cost of feed.	Per Pig.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1	19 18 3	5 3 8	14 14 7	3 18 8
2	19 0 3	5 7 2	13 13 1	3 8 3
4	17 18 6	4 18 10	12 19 8	3 4 11
3	17 13 3	4 15 4	12 17 11	3 4 6

Although the costs of feeding Groups 3 and 4 were lower than for Groups 1 and 2, the saving did not compensate for the lower value due to the smaller weights. The difference in the profit between Groups 3 and 4 of 5d. per pig, is particularly small, but the margin between Groups 1 and 4, those receiving 10 per cent. and 5 per cent. meatmeal respectively, was 9s. 2d. per pig.

The profit from Group 2, which received linseed meal in addition to meatmeal, was 3s. 4d. more per pig than in Group 3, to which the same proportion of meatmeal to grain was fed.

After curing, an examination of the sides was carried out, with Mr. H. A. Watson of Watson's Supply Stores. The results were most convincing and may be summarised as follows:—

1. The 10 per cent. meatmeal and the linseed meal groups made nearly the same growth. The amount of meat in the former was much greater than in the linseed group which were fatter.
2. The linseed sides were heavier than those of the 8 per cent. and 5 per cent. meatmeal groups but did not carry more meat.
3. There was a distinct and consistent variation in the amount of meat and fat in the three meatmeal groups—the 10 per cent. group having most meat and least fat, while the 5 per cent. group had most fat and least meat: in addition in the latter group the muscles were interspersed with layers of fat.

In order to ascertain whether the commonly held view that the feeding of linseed meal would cause a noticeable softening of fat and, as observation of the carcasses disclosed no apparent differences, samples of neck fat from each side—before curing—were submitted to the Government Analyst for iodine value determination with the following results:—

Group 1	62.0%
Group 2	63.5%
Group 3	61.7%
Group 4	61.8%

Sinclair in Canada (*Sc. Agric.*, Vol. XVIII., page 32) suggested the following scale for hardness:—

Below 63—hard.

63-67—medium hard.

Over 67—soft.

In this experiment, therefore, it may be concluded that the feeding of linseed meal had a slight softening effect on the fat, but not sufficient to cause any objection in the selling of the bacon. A cooking test of rashers resulted in three of four different homes suggesting that a slightly more soft condition of fat was noticeable than in the rashers from the other groups.

CONCLUSIONS.

1. Linseed meal replaced 30 per cent. of the meatmeal in the standard ration without seriously reducing the rate of live weight gain.

2. Eight per cent. meatmeal was not as successful as 10 per cent. measured by the rate of live weight gain, while the 5 per cent. meatmeal ration was not equal to that containing 8 per cent.

3. Owing to the higher costs of linseed and the slightly lower rate of growth, the margin of profit over cost of feed of Group 2 was lower than for Group 1, but was higher than for Groups 3 and 4.

4. The inclusion of linseed meal in the ration caused a small increase in the iodine value of the fat, but this was not sufficient to cause a degree of softening obvious on inspection.

5. The best proportion of meat to fat was observed in the group receiving 10 per cent. meatmeal: Group 2 which received 7 per cent. meatmeal and 6 per cent. linseed was about equal in this respect to Group 3 which received 8 per cent. meatmeal. The group which received 5 per cent. meatmeal had by far the greatest proportion of fat, which was not only in the form of a layer beneath the skin, but interspersed among the layers of muscles.

6. It is possible to grow pigs reasonably rapidly on a reduced ratio of meatmeal to grain. A profit over the cost of feed of £3 4s. 6d. per pig was obtained by feeding only 5 per cent.

ACKNOWLEDGMENT.

The assistance of Mr. H. A. Watson and his staff at the Spearwood Bacon Factory is acknowledged.

Maps of Perth and Suburbs.

A matter of interest to farmers and pastoralists, both at home and during visits to the City, has been brought to our notice by the Chief Draftsman of the Department of Lands and Surveys.

He has advised that a Metropolitan Road Map attractively printed in various colours, showing made and unmade roads, tram and bus routes, Road Board and Municipal boundaries, recreation grounds, parks, gardens and other useful information, is available at the Public Room of the Department of Lands and Surveys, Cathedral Avenue, Perth. Price 5s. unmounted, or £1 1s. mounted on calico with battens as a wall map. With the mounted copies a bound index to every street, road, etc., in the Metropolitan Area is supplied free, but if required with an unmounted copy the cost is 1s. extra.

The scale of the map is two inches to a mile and the size 30in. x 40in.

A similar map to the above, in black and white, 5ft. x 7ft., on a scale of four inches to a mile, is available with index and mounted on calico with battens at a cost of £3 3s.

A 10-mile series of topographical maps showing station properties, water supplies, fencing, roads, tracks, etc. over the pastoral areas of the State is in course of preparation and will be available for issue towards the end of the year.

The Chief Draftsman of the Department is available to advise the public on any mapping matters.

Superphosphate and Pasture Development in Western Australia.

THE FIRST SIXTEEN YEARS.

Adapted from a Report by V. B. Mussell, Assistant Manager, Cuming Smith and Mount Lyell Farmers' Fertilisers Ltd., W.A.

THE FIRST 20 YEARS OF THE CENTURY—1900-1920.

The first 20 years of this century saw the establishment of Western Australian agriculture with the main emphasis on the development of the wheatbelt. The importance of superphosphate in the growing of cereals was recognised from the beginning of the century, and its use became practically universal as the Western Australian wheatbelt took shape. With few exceptions, no one saw the prospects of an immense value in superphosphate for pasture production. It is true that many farmers used generous amounts of superphosphate with their sown crops in order to stimulate the succeeding pasture, but almost without exception, it was considered that the use of superphosphate solely as a topdressing for pasture production would not be a paying proposition.

It was during the later part of this period that the importance of superphosphate as a topdressing in the improvement of pastures and pasture development was recognised in Victoria and New Zealand. The results were spectacular. From reports received from allied companies in Victoria and New Zealand, the fertiliser manufacturers operating in Western Australia were convinced of the bright prospects for the extension of the superphosphate trade for the supply of superphosphate for the development of pastures, in spite of the totally different climatic conditions prevailing.

THE NEXT 20 YEARS—1920-1940.

While wheat-growing and the consequent use of superphosphate extended greatly after the 1914-1918 war, the outstanding development in Western Australia has been in pasture production. In this period the area of sown pastures has increased from a few thousand acres to approximately 1¼ million acres. In this development, two factors now regarded as virtually inseparable have been of paramount importance. These are superphosphate and subterranean clover. In this development the fertiliser firms have played a pre-eminent part, not only in the initiation of organised experiments to prove the value of the new methods of pasture establishment in Western Australia and to demonstrate the results to farmers, but also in the provision of many materials and expert assistance throughout this period. From the outset the administration wisely decided that its work would be arranged in association with officers of the Department of Agriculture and in collaboration with the district agricultural societies.

At the beginning of this period, the Department of Agriculture was very inadequately staffed, but every assistance possible was promised and given to the project. The fertiliser firms appointed a technical officer, and as the technical staff of the Department of Agriculture was built up under the direction of Dr. G. L. Sutton, the work extended and grew in strength and value. Although

initiated by commercial interests, this work from the outset was maintained as a sound experimental project, designed to secure results, primarily to establish the pasture development on a sound basis and build a sound and permanent industry. It has been the means of building a body of information on pasture development in Western Australia and has been used for advisory purposes throughout the State in just the same manner as other activities of purely departmental nature.

In the year 1922, while a few farmers were experimenting and succeeding with topdressing, there were no organised experiments. Clover was clover and grass was grass; it came away in the early spring and died away in the early summer, and that was an end of it. With few exceptions, all had the idea that our climate was too hot for pastures such as existed in New Zealand and some of the Eastern States. By the end of the period, 1¼ million acres of sown pastures were being topdressed annually, and the area was increasing rapidly. Unfortunately, this progress was stopped by war conditions.

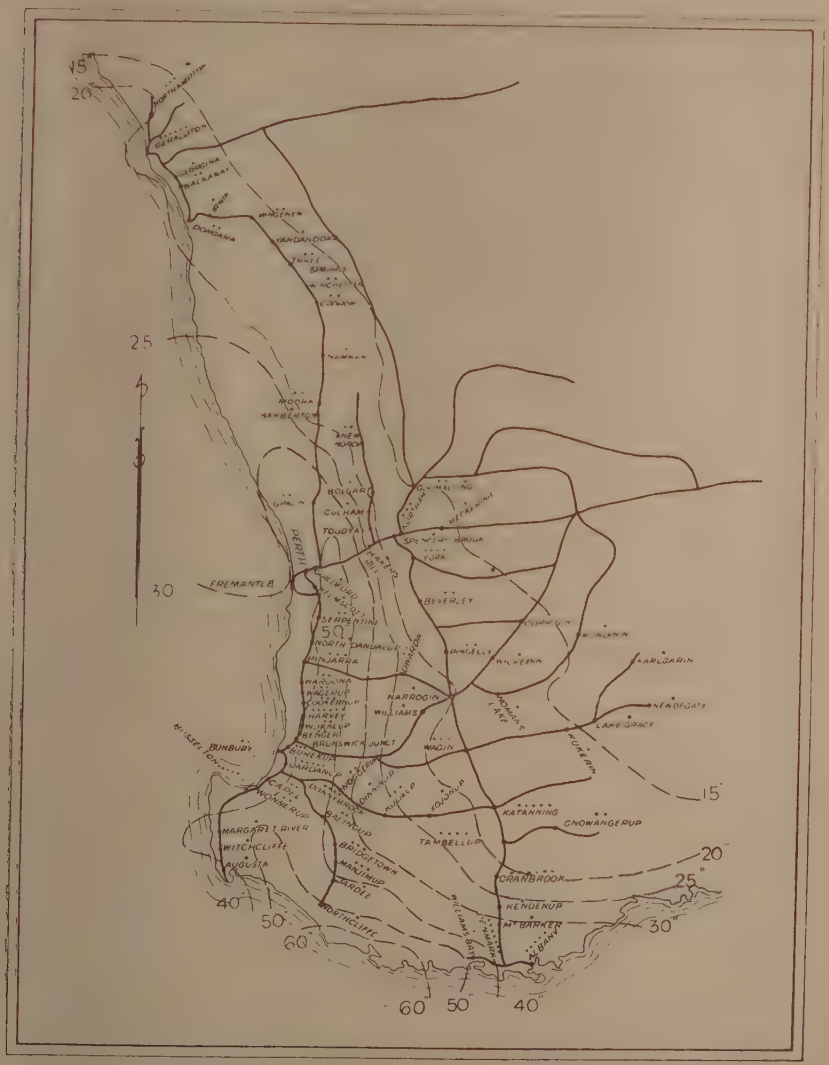
The Visit of Mr. J. J. Pascoe.

In August, 1922, Mr. J. J. Pascoe, agricultural adviser to allied fertiliser manufacturing companies in the Eastern States, was in Western Australia on wheat fertilising matters. This opportunity was availed of, and it was arranged that he visit possible pasture areas and submit his views so that independent advice would be available regarding propects in Western Australia as compared with the Eastern States. Mr. Pascoe's views were wholly favourable, and in September, 1922, he reported to his principals as follows:—

> Over what is really an immense stretch of country, I have seen the stimulating effects of grass fertilisation in patches here and there. It is an interesting fact, probably explained by the generous winter rainfall and the comparative poor supply of natural phosphate in the soil, that topdressing can be carried on in lower rainfall country than in Victoria. It is responding in 16 and 17 inch territory as well as in 40 inch. As good results are obtained north of Perth at Gingin, as at Bunbury, south of it. I have no hesitation, therefore, in saying that wherever the soil above the 16 inch rainfall is good enough to carry a pasture topdressing will respond and can be safely recommended. There is no problem attached to it as in the wheatbelt; propaganda can be conducted to the extent that the companies are willing to go. On the rich flats the response is as good as in Victoria, with the exception that there is an absence of useful grasses in the western State. There is also evidence to show that poor sandy stuff, not unlike the Heytesbury Forest country at Nullewarre, can be built up. At several places—at Gingin, Benger, Dardanup, Serpentine and Upper Swan—I have seen it responding almost magically on similar areas. This fact opens up big possibilities inasmuch as when properly appreciated it may lead to the clearing of millions of acres of second and third-class lands in the high rainfall districts:

The area included in the rainfall belt referred to by Mr. Pascoe covers 35 million acres. Not all of this may be suitable for pasture production, but there is no doubt that a very considerable proportion of that still undeveloped may confidently be regarded as potential pasture and agricultural land not greatly different from that already established. In view of Mr. Pascoe's report, the fertiliser manufacturers decided to proceed with the establishment of a number of experimental plots to prove in the first instance whether pastures of clovers and natural grasses could be established by topdressing with superphosphate.

Proposals were discussed with the Department of Agriculture and the Royal Agricultural Society, who offered to help but were plainly not sanguine of success. The next step was to communicate by letter with selected country agricultural societies to enlist practical help amongst the farmers themselves.



Map of the South-Western portion of the State showing the isohyets, the railway skeleton and the location of Pasture Experimental Plots laid down during the years 1923-1939.

The Approach to the Country Societies.

Letters were sent to 15 agricultural societies on 19th December, 1922. Of these, two accepted the offer, two definitely declined, and the remainder failed to reply. Following a further letter sent on 25th January, 1923, two additional

societies accepted, two declined and the remaining seven ignored the request. This unsatisfactory response led to a personal visit by officers of the fertiliser manufacturing firms in company with officers of the Department of Agriculture where possible.

This party met with varied receptions. In one district, the farmer selected sent out a message to the party that "his day for salesmen was Thursday," and on further representations replied that "no good would come of any such experiment." The use of subterranean clover and topdressing in this district has proved revolutionary of recent years. At another district, the farmer himself promised five acres for the experiment, but a member of his family intervened and prevented it.

Of the 10 districts visited, arrangements were made for experiments at eight sites. Three sites were subsequently selected in the Midlands districts, making a total of 11 for 1923. In 1924 further lots were laid down, bringing the total to 21, and in 1925 15 of the plots were continued under the programme laid down.

The First Plots.

As simplicity was of paramount importance in the first approach, a 5-acre plan as recommended by Dr. A. E. V. Richardson, then Agricultural Superintendent of the Department of Agriculture in Victoria, was adopted. The area was selected facing a main road with soil of general average quality and no seeds whatever were sown. Fertiliser was applied in early autumn under the direction of the president of the local agricultural society and associated with the Agricultural Officer when convenient. In this layout, the 5-acre block was divided into three sections—two outer sections of 2 acres and a central section of 1 acre. One of the 2-acre sections was topdressed with superphosphate at the rate of 2 cwts. per acre and the other at the rate of 1 cwt. per acre, leaving the centre section unmanured. The total area was fenced off from stock and signboards erected so that the results could be watched by farmers in the district. These experiments were laid down in 1923.

It is of interest that Mr. W. J. Gillett, of Northam, can claim to have had the first official pasture experiment in Western Australia laid down on his property.

Taking the season of 1925 as a typical one, the plots showed an increase in green fodder from the section fertilised with 1 cwt. of superphosphate varying from 130 to 700 per cent. over the unmanured section, and that fertilised with 2 cwt. per acre, an increase of 176 to 800 per cent. The general average over the whole of the plots showed an increase in edible feed of 271 per cent. for the 1 cwt. section and 328 per cent. for the 2 cwt. section, with a general average increase of clovers of 305 per cent. and 370 per cent. respectively. A sample of clover taken from one of the Harvey plots and analysed by the Department of Agriculture showed that clover from the manured section was 116 per cent. greater in fat than from the unmanured section, 46 per cent. greater in starchy matter, 24 per cent. greater in nitrogenous matter, while the crude fibre was reduced 62½ per cent., from 31.57 per cent. where unmanured to 14.12 per cent. where manured with 2 cwts. of superphosphate per acre. These results are discussed in detail by G. K. Baron Hay, 1926.*

* Journal of Agriculture, Western Australia: Volume 3, 1926, pages 185 to 193.

The interest in these experimental plots developed, and sites were selected and established in succeeding years until in 1930 a total of 78 had been established. In that year the series was terminated, as it was considered that the maximum amount of information had been obtained from experiments of this design. In this period, great progress had been made and the area of sown grasses and clovers had increased from 17,000 acres in 1920 to 339,000 acres in 1930.

The Introduction of Grasses and Rotational Grazing Trials.

With the conclusion of the first series of experiments it was decided to conduct experiments on the incorporation of suitable imported grasses with our clovers and to observe the reaction of the pasture mixtures under grazing. Very special attention was given to the incorporation of imported grasses, particularly as it was found that the luxuriant growth of clover was in many instances crowding out our natural grasses, thereby losing to some extent the balance, however poor, our natural grasses gave to the clovers. In the first endeavours to introduce grasses, the ground was first harrowed thoroughly and the seeds of such as perennial rye grass, Wimmera rye grass, Akaroa cocksfoot, and White Dutch clover, sown. The results were very poor, and it was ascertained that harrowing only in Western Australia was inadequate for the establishment of these species. Plowing and thorough cultivation were necessary. The rotational grazing trials were continued for a number of years and valuable information obtained in regard to the better grasses for incorporation with the clovers. The rotational grazing trials enabled the selection of promising grass species to be made and nursery plots of these were established on key farms to demonstrate to farmers the behaviour of the different grasses and to provide a supply of seed for the extension of the plots or the planting to large areas. Some 76 of these nursery plots were soon in operation and continued during 1933, 1934, and 1935. The mixtures were perennial rye grass and White Dutch clover; Akaroa cocksfoot and White Dutch clover, and Phalaris tuberosa and White Dutch clover. These proved of considerable educational value, in that a very large number of farmers in these districts saw the grasses actually growing under local conditions.

Introduction of First Early Subterranean Clover.

During the previous 10 years the immense value of subterranean clover in conjunction with natural grasses became known everywhere. It spread like a miracle over the whole of our South-West and Great Southern, and even in several parts with a rainfall of 20 inches and over. In order to stimulate the introduction of subterranean clover under somewhat drier conditions, prizes were offered for the demonstration of subterranean clover establishment with superphosphate in the Geraldton district. The competition was judged by an officer of the Department of Agriculture and demonstrated the productiveness of first early subterranean clover in the Geraldton district. On the winning area at Irwin, the unfertilised portion yielded 1 ton 9 cwts. of green herbage per acre, 25 per cent. of which was clover, while the topdressed portion yielded 12 tons 5 cwts. of green herbage per acre, 74 per cent. of which was clover.

Plots demonstrating the value of first early subterranean clover in association with superphosphate for the improvement of pastures in the areas of intermediate rainfall have been established in a number of centres from Geraldton to the Lower Great Southern and have been of very considerable demonstrational value.

The Statistical Story.

The story of the development of pasture in Western Australia and the collateral increase in the use of artificial fertilisers and in dairy production, is illustrated by figures taken from the Statistical Register and shown in Table 1 and the accompanying graph.

TABLE 1.

WESTERN AUSTRALIA.

Figures from the Statistical Register of Western Australia and from the Commonwealth Year Book Showing the Use of Artificial Fertilisers, Chiefly Superphosphate, the Area of Crop Fertilised, Sown Pastures Topdressed, and Milk Obtained for Western Australia.

Year.	Artificial Fertilisers.	Cropped area.	Area of sown pastures.	Pastures top-dressed.	Super used on pastures.	Dairy Production milk.
	tons.	1,000 acres.	1,000 acres.	1,000 acres.	tons.	million gallons.
1910–11	33,194	855	...	...	...	...
1920–21	66,602	1,805	17	...	...	10·2
1921–22	73,029	1,902	18	...	...	11·3
1922–23	86,000	2,275	25	...	...	11·9
1923–24	92,055	2,323	38	20*	1,000*	13·0
1924–25	110,626	2,711	60	40	2,000*	13·4
1925–26	128,092	2,932	89	78	3,900*	14·8
1926–27	145,795	3,325	129	125	6,250*	15·6
1927–28	169,552	3,220	169	219	10,950*	17·2
1928–29	201,022	4,259	244	313	15,650*	18·3
1929–30	231,128	4,566	324	407	20,350*	21·4
1930–31	236,146	4,792	339	500	25,000*	24·3
1931–32	178,509	3,963	371	594	29,700*	29·9
1932–33	199,337	4,263	431	680	34,000*	33·6
1933–34	203,848	4,217	440	770	38,500*	34·9
1934–35	196,741	3,841	501	844	42,200*	36·8
1935–36	202,325	3,756	578	880*	44,000*	38·1
1936–37	224,473	3,886	636	974	48,768	37·0
1937–38	249,640	4,204	756	1,068	54,714	41·4
1938–39	280,384	4,721	908	1,259	63,648	44·8
1939–40	270,478	4,333	1,085	1,284	66,346	45·9

* Estimates by Mr. V. B. Mursell, Cuming Smith & Mount Lyell, Perth.

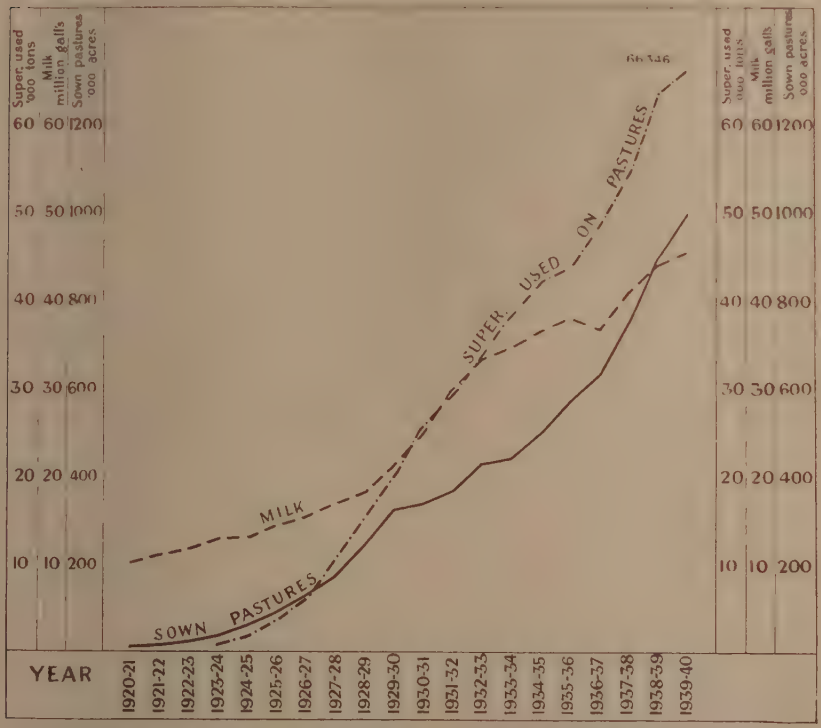
Our Problems.

A lot of ground has been covered during the last sixteen years, but a great deal more needs to be done before we can hope to have general results equal to those of some of the other parts of Australia and New Zealand.

We are constantly being reminded of our problems, how they differ from those of other States owing to our unusual climatic and soil conditions, how they can only be remedied by extensive research work, and so on. It is true that there are many problems involved in the development of any new country. These problems are not a guarantee of failure, but a promise of reward for achievement when they have been solved by hard work, initiative and full application of modern science. Perhaps there has been too great an emphasis on our problems with the implied suggestion of insurmountable difficulties. This is certainly a false interpretation. It is essential that our problems be recognised in order that they may be attacked

and overcome. The very fact of the spectacular progress which has been made in Western Australia shows that this attitude has been adopted because each advance has involved fresh adjustments to a changed environment. It is realised that the immediate opportunities are virtually limitless.

In our endeavours to meet the economic needs of the industry, we must search for the cheapest and most effective methods of development. We must experiment with a view to improving fertiliser practice. The search must be continued for better species and improved strains in our pastures, for better stock, better husbandry and better farm equipment. There are vast empty spaces between the clearings in Western Australia awaiting development, presenting a challenge to our nation.



Graph illustrating correlation between pasture establishment, superphosphate used in top-dressing and dairy produce (milk) obtained during the years 1920-21 and 1939-40.

The Co-operative Attack.

The challenge must be accepted. Our farmers have proved themselves in developing a competence in pasture and stock management in the course of a few years. In every district there is at least one man, sometimes several, who stands out as successful. These men are contributing a great deal in the working out of agricultural methods and offer an outstanding example to their neighbours. These men offer a measure of what can be done in the future when their experience has been absorbed into the agricultural practice of their districts. Our farmers have been backed by extraordinarily good work by officers of the Department of Agriculture, carrying on under the most lamentable conditions. In a number of fields

they have risen above the handicaps of poor equipment and inadequate housing to solve problems which have baffled scientists elsewhere for decades. Farmers have been quick to adopt the measures discovered by our research workers and these contributions have been of immeasurable benefit to agriculture.

Another important factor is the efficiency of our business organisation and faith in our country by the business man. Sales organisation, markets without waste and a fair return to the grower are essential for progress.

While there is need for more farmers, for more research workers and for closer relationship between the business and farming interests, perhaps the most obvious need now is in the field of the extension worker. More publicity is needed. There is need for a wider dissemination of the principles of farming and the application of these principles to Western Australian agriculture. There is nothing more important than the personal approach and the farmer needs the extension worker to advise him on his every-day practices to bring to him the latest information available on agriculture; the research worker needs him in the identification, diagnosis and attack on the multifarious problems of agricultural progress; the business man can look to him for information fundamental to his part in the service of the agricultural community. With all this, there must be developed an appreciation that the farmer and his family are entitled to a reasonable standard of living in order that he may attain a higher degree of efficiency in his primary production and in the end make his contribution to the benefit of everyone.

During the period 1933-1939 the Commonwealth Government granted a bounty on superphosphate used for the top-dressing of pastures. In the three years 1933-1936, 15s. per ton was rebated from the price of superphosphate; in 1936-1937, this was reduced to 10s. per ton and a further restriction was imposed in 1937-1938 when 10s. per ton was rebated on a maximum of 20 tons. In 1938-1939 the maximum was reduced to 10 tons, after which year the bounty was discontinued.

The Bed Bug.

(*Cimex lectularius* L.)

C. F. H. JENKINS, Government Entomologist.

General Description.

Bed bugs are flattened, reddish-brown wingless insects, measuring about ¼in. in length when fully grown. They possess sucking mouthparts and feed upon mammalian blood, particularly that of man. If squashed the bug emits a nauseating odour which is characteristic of many of the bug family, and by which any doubts as to the identity of the creature may be speedily dispelled.

Life History and Habits.

The female deposits comparatively large yellowish white eggs in the cracks and crevices used as hiding places. Over a period of several months a single insect may lay from 200 to 500 eggs. The young, which have the general form of the adults, hatch in about ten days, and maturity is reached after a further five or six weeks. The duration of the different stages in the life cycle may be greatly

lengthened under adverse temperature and food conditions. Normally fed the adults will live about a year, and starved individuals have been known to survive for 136 days. This latter fact is of considerable importance when considering control measures against the pest, for it emphasises the difficulty of starving out an infestation.

Relation to Disease.

The bed bug appears to be relatively unimportant as a disease carrier, but nevertheless should be regarded as a possible menace to public health.

Sources of Infestation.

It is sometimes very difficult to account for outbreaks of bugs in well-cared-for homes, but when the retiring habits of the pest and its amazing ability to go long periods without food are borne in mind, the ease with which the insect may be transported in secondhand furniture, or be picked up in public conveyances, will be apparent.

Adult male bed bug seen from above. (Enlarged.) (U.S.D.A.)

Control.

Fumigation is the most effective treatment against a severe infestation of bugs, but sprays may be used satisfactorily against light outbreaks.

The cracks and crevices in walls and furniture should be thoroughly treated, special attention being given to gaping skirting boards and articles of furniture such as beds, which should be dismembered as much as possible so that spray liquids are able to contact all parts. Wire mattresses should be thoroughly saturated and particular attention should be paid to stuffed mattresses, for egg masses are often deposited around the buttons used in connection with the sewing to keep the kapok or other stuffing in place.

Fumigation.

Fumigation is undoubtedly the most effective treatment against bed bugs, and the only one which should be considered where a well-established and serious outbreak requires attention. Various materials are effective against the pest, but the one most universally used is hydrocyanic acid gas. On account of the highly toxic nature of this gas it should only be used by experienced workers. The standard formula for the preparation of the gas is as follows:—

Sodium cyanide, 1 oz.
Commercial sulphuric acid, 1½ ozs.
Water, 2 fluid ozs. (a fluid oz. equals 2 tablespoons).

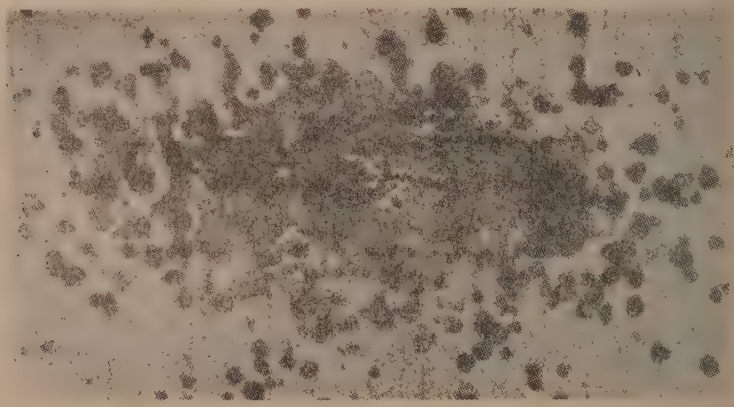
Preparations such as zyklon B, liquid hydrocyanic acid, and cyanogas dust A may be used as sources of this fumigant.

In the case of a house every room requiring treatment should be treated as a separate entity and be made thoroughly airtight. This may be achieved by pasting up the ventilators and cracks around doors and windows with strips of paper. The dosage required for a room may be worked out on the basis of 1 lb. of cyanide to 1,000 cubic feet of space.

In preparing the mixture the sulphuric acid should be poured into the water and not vice versa, and the cyanide should be suspended over the earthenware crock containing the liquid, in a paper bag and lowered in as the door is being closed.

Rooms treated with hydrocyanic acid gas should be left sealed for at least 12 hours. Then a thorough airing should be given to ensure that all traces of the gas have been removed before anyone is allowed to enter the building.

Sulphur.—Sulphur is sometimes used as a fumigant and is quite effective if burnt at the rate of 2 lbs. of sulphur to every thousand cubic feet of floor space. Where sulphur is used the risk of fire must always be borne in mind, however, and it should also be noted that any metalwork in a room is liable to be tarnished.



Patch of stains which always indicate bed bug hiding places. (U.S.D.A.)

Sprays.

Where sprays are used they must be applied copiously so as to penetrate cracks and crevices and thoroughly wet any hidden insects. The following formulae will be found effective:—

1. Kerosene or petrol, 1 gallon.
   Cresol or carbolic, 1 pint.
2. Kerosene pyrethrum fly spray.

The latter is prepared as follows:—Steep ¾ lb. pyrethrum in 1 gallon of kerosene for 24 hours, and then strain off the liquid. Three ounces of methyl salicylate may be added to the mixture to impart a more pleasing odour.

However thoroughly applied a single spray cannot be expected to be entirely effective and treatment must be repeated two or three times at about ten-day intervals. Eggs laid in well-protected situations may easily be missed by the spray and if young bugs emerging from these are not promptly dealt with they will rapidly breed up again to carry on the infestation.

ACKNOWLEDGMENT.

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Studies in Sheep Husbandry in W.A.

V.—THE BREEDING SEASON OF MERINO, CROSSBRED AND BRITISH BREED EWES IN THE AGRICULTURAL DISTRICTS.

E. J. UNDERWOOD, F. L. SHIER and N. DAVENPORT.

Most sheep breeders now appreciate the fact that all breeds of sheep, including merinos, have breeding and non-breeding seasons in each year and that during the non-breeding season they do not exhibit oestrus (heat) and accept service from the ram. In Australia this fact was first demonstrated experimentally by Kelley (1937) and Kelley and Shaw (1943) through the use of raddled vasectomised ("teaser") rams. The work was carried out in the Eastern States at field stations at Cunnamulla, Queensland; near Sydney, N.S.W.; and at Cressy, Tasmania. It related principally to merinos, although the breeding seasons of some British Breed and Crossbred ewes were also worked out. Kelley's results led to the broad, general conclusion that "the breeding seasons were in late summer, autumn and winter months and not in those of late spring and early summer."

It is generally recognised, however, that the commencement of the breeding season varies somewhat in different years even with the same type of sheep in the same locality. It seems not unlikely, therefore, that the different climatic conditions of W.A. as well as differences in strains of sheep and nutritive conditions, might result in a rather different breeding season from those obtained in Kelley's studies. Further, as Kelley admits, long continued spring and summer matings may result, by selection, in a type of merino which will breed at this time. All these factors point to the desirability of determining the optimal mating times, from the point of view of maximum lamb drop, for particular flocks and localities. No such data were available for the agricultural areas of W.A. prior to the results presented in this paper. The climatic conditions of these areas, however, definitely point to the desirability of early summer mating, so that lambing will in general coincide with the advent of green grazing, following the long, dry summer period. Lambing at this time is necessary if the lambs are to have the full benefit of the rather short season of good nutritive conditions.

AVONDALE EXPERIMENTS.

In December, 1940, oestrus observations with vasectomised merino rams were commenced on a group of 25 first cross Merino x Border Leicester maiden two-tooth ewes, approximately 18 months old, using the technique described by Kelley (1937). In March, 1941, a group of 25 four-tooth (2½ years) Murray blood (S. Aust. type) merino ewes which had previously produced lambs were added to the experiment. The observations were continued with the crossbred ewes until October, 1942, when this group was replaced by one of 25 full-mouth (4½ years) ewes of similar breeding which had previously produced lambs. The observations were then continued with both groups until March, 1943, when shortage of staff and other activities necessitated their cessation. The climatological conditions of Avondale have been described previously (Underwood and Shier, 1941).

RESULTS.

These have been graphically represented in Fig. I for the merinos and Fig. II for the crossbreds. These graphs clearly show that for the both groups under test there were marked breeding and non-breeding seasons each year.

In the case of the merinos sexual activity began to fall markedly from March, 1941 (when the observations on this group commenced). Most of the ewes were in anoestrum in late autumn, winter, spring and early summer. In 1942 the period of quiescence was shorter. The fall in sexual activity commenced in April-May (autumn), but was not so marked as in the previous year. However, by July (mid-winter) only 46 per cent. of the ewes were in season and from then on during spring until December they were largely in anoestrum. The commencement of the breeding seasons in the two summers 1941-42 and 1942-43 was very sudden. In January in the former and December in the latter practically 100 per cent. of the ewes were in season.

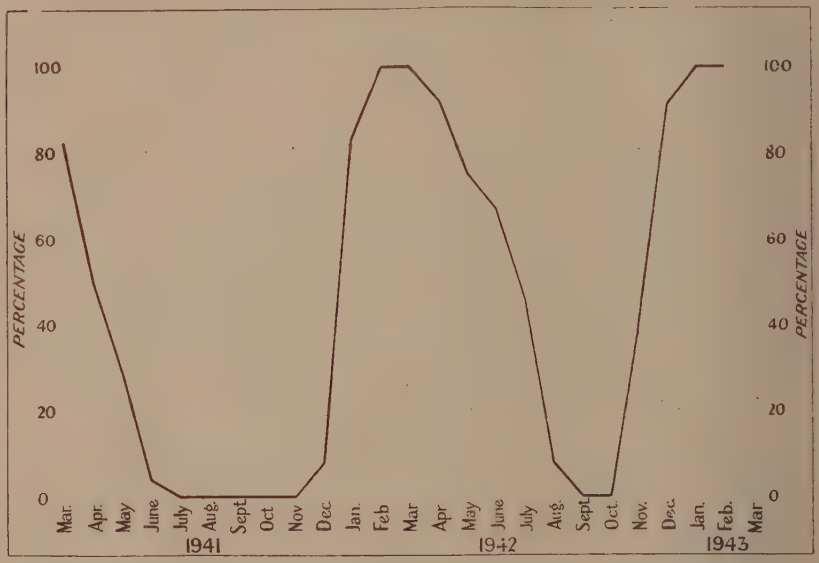

Fig. 1.—Graph showing monthly percentage incidence of oestrus in Merino ewes (S. Aust. type) at the Avondale Research Station from March, 1941, to March, 1943.

The data presented indicate that the merino ewes examined were in season in summer and largely so in autumn but during winter and spring they were in anoestrum or in a very low state of sexual activity. It should be emphasised that this conclusion is only strictly applicable to similar ewes under the same environmental conditions.

The data for the crossbreds (Fig. II) show that in the first summer (1940-1) the breeding season of the ewes (maiden two-tooths, 1½ years old) was of short duration. It extended over the autumn period only (March-May). An odd ewe showed oestrus in December and January, but it was not until February that the sexual season really commenced. Forty-six per cent. of the ewes were served during this month and 90-100 per cent. during the following three months. In the following summer the ewes, as four-tooths, again showed practically no sexual activity in December and January but almost 100 per cent. were in oestrus in February. The breeding season lasted from this time until June, when the number of ewes exhibiting oestrus began to fall rapidly. During the rest of the winter and the whole of spring most of the ewes were in anoestrum.

In November these ewes were replaced by a group of more mature ewes of the same breeding, all of which had previously produced lambs. Some of the ewes began to show oestrus immediately, and during January to March most of them were on heat. The observations were concluded at this time so that the end of the breeding season could not be determined.

From these data it is apparent that the breeding season of first cross Merino x Border Leicester ewes is during late summer and autumn and that the period of maximum sexual activity commences approximately one month later than with the merinos. The later commencement of the breeding season in 1941-42 and to an even greater extent in 1940-41, compared with the following summer is probably due, at least in part, to the fact that the ewes were, in 1940-41, maiden two-tooths. The general experience with maiden two-tooths is that they have a shorter and later first breeding season than more mature ewes. Climatic differences in the three seasons can also be included as possible influences.

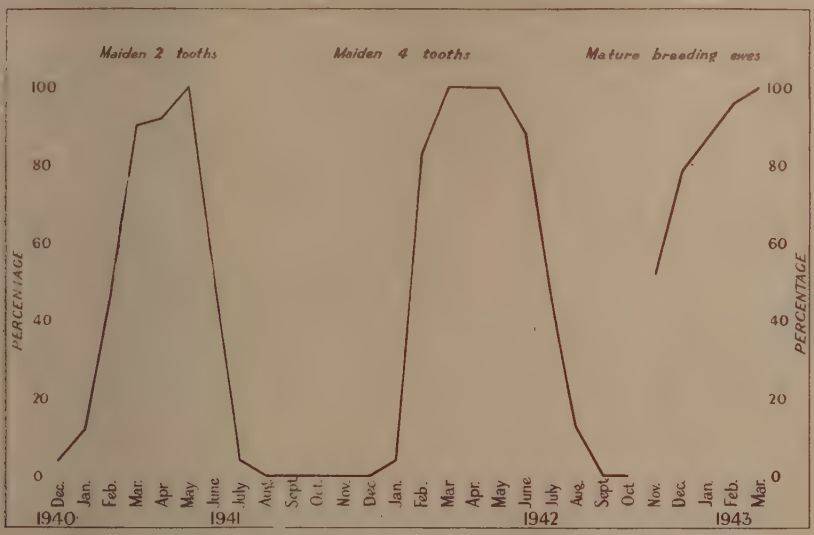

Fig. 2.—Graph showing monthly percentage incidence of oestrus in crossbred (Merino x Border Leicester) ewes at the Avondale Research Station from December, 1940, to March, 1943.

DATA FROM OTHER SOURCES.

Merinos.

Considerable information on the breeding season can be obtained from actual lambing records. In the agricultural areas of W.A. an April lambing is favoured and practised by most merino breeders. Lambing is generally completed in merino flocks by the end of May. At the Merredin Research Station (160 miles east of Perth) the times of joining the rams with the ewes and the lambing details of the pure breed Stud Murray blood flock have been recorded for the years 1942, 1943, and 1944. The usual practice has been to join the rams and ewes during the first week in November.

In 1942 lambing commenced on April 8th, was at its peak from the 22nd of this month and was practically complete by 2nd May. In 1943 lambing commenced on 6th April, was at its peak about 14th April and was complete by 8th May. In the present season the position is that lambing commenced on 30th March, was at its peak about 12th April and was complete by the end of the month.

In the three seasons the lambing ranged from 87-90 per cent.

These lambing details demonstrate clearly that the breeding season in these Murray blood ewes (South Australian type) is in full swing in November at Merredin. Although the rams were kept with the ewes during December in each year the number of lambs conceived in this month was negligible. These results do not, of course, preclude the possibility that the ewes reached maximum sexual activity *earlier* than November, but they do indicate that the ewes were in full oestrus at least one month earlier than would be anticipated from the oestrus observations on ewes of similar breeding at Avondale. The Merredin data, however, support the Avondale observation that the South Australian type of merino ewes are in a high state of sexual activity in the summer months and will breed during this period.

No experimental evidence or definite field data on the sexual behaviour of other strains of merino ewes are available but the general experience amongst farmers indicates that the Riverina type of merino reaches maximum oestrus incidence by December. The poor results obtained by many farmers who have attempted summer lambing indicates further that most merino ewes are in anoestrum during spring.

Crossbreds.

At the Avondale and Chapman (320 miles north of Perth) Research Stations a number of experiments with sheep have been carried out since 1936. From these experiments individual details of dates of service (obtained by the use of entire rams raddled on the brisket) or dates of lambing or both have been obtained for a number of large groups of first-cross Merino x Border Leicester ewes. In those cases where lambing dates only are available the dates of service have been calculated from a standard gestation period of 150 days. The complete service data is presented in three-day periods in graphical form in Fig. III for Avondale and in Fig. V for Chapman. Only four curves are plotted on each graph to avoid making them unduly complicated. It should be stated, however, that other data are available which show essentially the same picture.

From both graphs it is apparent that the ewes show a marked variation from year to year in the date of maximum incidence of oestrus. The spread in time between the earliest and latest onset of full sexual activity in different years is about 3-4 weeks. The earliest time of maximum onset of oestrus at Avondale was about December 27th, 1943, and the latest about January 23rd, 1942. At Chapman the corresponding dates were December 19th, 1941, and January 4th, 1941. From these figures it would appear that at Chapman the ewes reach maximum sexual activity about two weeks earlier than at Avondale. The Avondale data in Fig. III is in agreement with the rather limited oestrus observations at that Station which show that in some seasons crossbred ewes of this type are in full sexual activity in December.

A point of great interest which arises from Figures III and IV is the rhythmic fluctuation or "modal" distribution of the daily incidence of oestrus and of lambing in all the groups of ewes in the different years. Attention has been drawn

to the phenomenon previously by Underwood and Shier (1941). When a large group of ewes is mated during their breeding season to a sufficient number of active rams it would be expected that the graph of daily oestrus incidence would approximate to a single normal frequency distribution curve for the whole group. Instead of this the graph in each instance is made up of two or more "peaks" of maximum activity, each approximating to the shape of a normal frequency curve and separated by a period of about 17 days, which is the average dioestrus period. In the case of Fig. IV which is calculated from lambing data, it might be argued that the second and third peaks are due to ewes failing to conceive at the earlier oestrus periods but

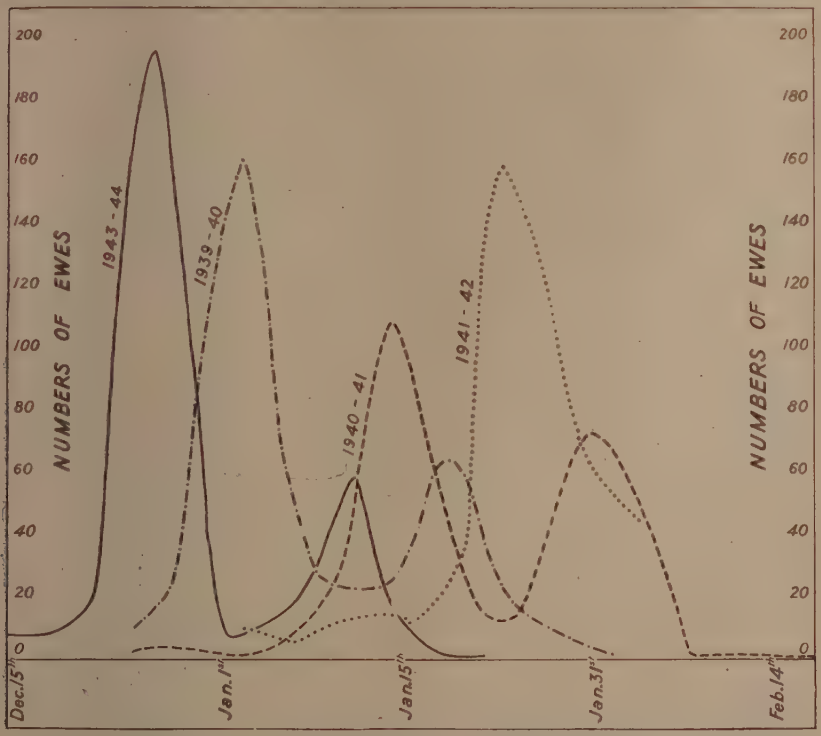

Fig. 3.—Graph showing the periodic intensity of oestrus incidence in groups of Merino x Border Leicester ewes at the Avondale Research Station. Note the different times of the occurrence of the maximum intensity in different seasons and the two "peaks" separated by a period of about 17 days in each year. (See text.)

the curves in Fig. III are very similar, although they were obtained from actual oestrus incidence observations with raddled entire rams *in which the ewes once served were immediately removed from the flock.* It is possible that the second "peak" is made up, at least in part, of ewes which had shown "silent heat" at the time of the previous peak. Kelley and Shaw (1943) found a varying percentage of "silent heat" in normal ewes during the breeding season The smaller *size* of the second peak in each case is obviously due to the fact that most of the ewes would be in lamb at the time of the second "wave." From these results it would appear that the ewes as a group react very suddenly and completely to the factors which cause the onset of sexual activity following anoestrum. From the practical point of view it follows that for a concentrated lambing over a short period of time it is unwise to use too few rams.

British Breeds.

Although no detailed observations of the seasonal incidence of oestrus have been made with the British Breeds some information on this point was obtained from an experiment designed to test the value of a commercial gonadotrophic hormone preparation in inducing oestrus in English Leicester ewes (Underwood and Shier, 1942). Twenty of these ewes were available for study, of which two showed oestrus in December, nil in January, ten in February and eight in March. This data is somewhat limited but confirms the general observations of farmers that the pure bred British Breed ewes (with the exception of the Dorset Horn) do not commence their breeding season until February or March. General experience amongst farmers indicates that Dorset Horn ewes reach maximum sexual activity at a similar time to merinos viz., November and December.

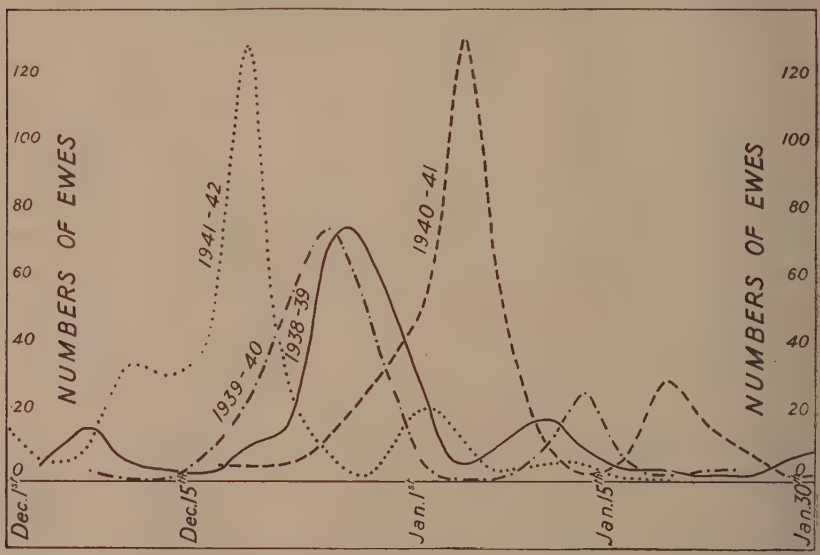

Fig. 4.—Graph showing the periodic intensity of oestrus incidence in groups of Merino x Border Leicester ewes at the Chapman Research Station, calculated from daily lambing data using a standard gestation period of 150 days. Note the same phenomena as in Fig. 3. (See text.)

DISCUSSION.

From a consideration of the data as a whole it is clear that in the agricultural areas of this State maximum sexual activity or incidence of oestrus is reached in November and December (early summer) by merinos; in late December and January (mid-summer) by crossbreds (Merino x Border Leicester); and in February and March (late summer and early autumn) by British Breed ewes, with the exception of the Dorset Horn. It appears also that these ewes are in anoestrum or a very low state of sexual activity from about July to October (late winter and spring). The Merredin Research Station data show quite definitely that a highly successful April lambing (November mating) can be regularly obtained at this centre with the South Australian type of merino. Equally successful results from mating at this time is obtained both with this and other strains of merinos in many parts of the agricultural areas. Earlier mating has been tried by some farmers with variable results but the bulk of the evidence indicates that low percentages generally result from September-October matings.

The finding that in the agricultural areas of W.A. merino ewes reach maximum incidence of oestrus in early summer does not entirely support Kelley and Shaw's (1943) finding that "the breeding season is in late summer, autumn and winter months and not in those of late spring and early summer" and definitely rules out the suggestion "that (this) rhythm will be general throughout Australia." Kelley's conclusions have been drawn from oestrus incidence studies of ewes continuously exposed to vasectomised rams over a wide range of climatic conditions extending from Cunnamulla (Queensland) to Cressy (Tasmania). He points out, however, that his observations have "particular reference to certain sheep in specific environments" and may require modification for other sheep in other localities. It is very apparent from our data that this is so.

There are at least two possible explanations of the difference in our results and those from the much more extensive work in Eastern Australia cited above. In the first place, although Kelley's observations were made over a wide range of latitude and of climatic conditions, in no case do these climatic conditions approximate very closely to those which exist in the area under review in W.A. So little is at present known of the real nature of the climatological (exteroceptive) factors and their interaction which influence sexual activity that there is no point in attempting to compare or contrast conditions in W.A. and the Eastern States. It is obvious, however, that differences may exist in the early summer in W.A. sufficient to account for the earlier onset of the breeding season. It might be noted, however, that ewes in the southern areas of this State reach maximum sexual activity under conditions of rising temperatures and increasing hours of daylight compared with Kelley's work where the reverse is true.

The possible influence of the genetic factor can also not be ruled out. In W.A. in the agricultural areas the desirable lambing time is restricted to late autumn on account of the shortness of the following period of green grazing. The continued early summer mating, which lambing at this time demands, might therefore have resulted, through unconscious selection, of a strain of sheep with an earlier breeding season. No experimental evidence can be advanced in support of this hypothesis, which is pure speculation. The only data available involving a direct comparison of the oestrus incidence of merinos in the southern areas with similar sheep in another environment are those arising from the work of Stewart and Moir (1943). These workers made oestrus observation at Warralong Station, 900 miles north of Perth in the summer rainfall zone, on a group from a random selection of the same flock of merinos from which the group tested by the writers at Avondale Research Station were obtained. Unfortunately, owing to the war situation, Stewart and Moir's work had to be curtailed after about six months' observations. It should be noted, however, that in the 1941-42 summer the period of onset of oestrus was very similar at the two places, in spite of the great difference in climatic conditions.

The question of the difference between the results of Kelley (loc. cit.) in Eastern Australia and W.A. experience and on the difference between our own oestrus observations with merinos at Avondale and the Merredin data is of considerable interest. The oestrus observations at Avondale indicate that merino ewes do not reach maximum oestrus incidence until about one month later than would be expected from actual experience and records at Merredin and elsewhere. The different environmental conditions at Avondale and Merredin Research Stations, although slight, may, of course, play their part in producing this difference, but a more likely explanation is concerned with the fact that under farm conditions the rams are only with the ewes during the mating period, whereas the technique of

seasonal oestrus incidence studies involves continuous association of the ewes with the rams. There is an indication from our experience that rams placed with ewes, which have been separated from the ram for some months and which are approaching the breeding season, have some effect in bringing the ewes into "heat."

The following table (Table I) taken from the records at the Chapman Research Station with merino and Border Leicester ewes is of significance in this connection.

TABLE I.

Year of Drop.	Rams joined with ewes.	Due Date of Lambing.	"Peak" drop of Lambs.	Period between "due" date and peak drop.
		(150 days)		days.
1939	5-12-38	3-5-39	25-5-39	22
1940	7-12-39	6-5-40	24-5-40	18
1941	16-12-40	15-5-41	3-6-41	19
1942	1-12-41	30-4-42	18-5-42	18
1943	7-12-42	6-5-43	26-5-43	20

In view of the comparative constancy of the figures in the final column of Table I it is difficult to resist the conclusion that the rams have had some influence on the sexual activity of the ewes.

A similar lag between the time of mating and maximum onset of oestrus, as determined by the use of raddled entire rams or from lambing data has also been noted in all of the data from Chapman and Avondale. At first sight it seems only reasonable to expect, at least in some of the 15 years available for study, that the time of joining of the rams would coincide with the "peak" of maximum intensity of sexual activity in the ewes. This never occurred and there was a fairly constant delay each year. It is suggested that the ewes under study were approaching their breeding season at the time the rams were joined and these fresh rams had a very marked effect in bringing the ewes into a state of high sexual activity. When rams are placed with ewes at such a time they apparently influence markedly factors within the ewe which govern the onset of sexual activity.

It would be exceedingly interesting to test critically this finding by mating large groups of similar ewes at a series of fixed times before and during the breeding season. An experimental study of the influence on oestrus incidence of continuous association with the ram compared with intermittent association is at present being made at Cunnamulla, Queensland (Bull. 1943).

SUMMARY.

The results of oestrus incidence studies with Merino and Merino x Border Leicester crossbred ewes at Avondale Research Station, Beverley, using vasectomised rams, together with data regarding the breeding season of merinos at Merredin Research Station and of crossbreds at Avondale and Chapman Research Stations, as disclosed from dates of service and of lambing, are described.

It is concluded that in the agricultural areas of W.A. the breeding season commences, i.e., the maximum onset of oestrus is reached in November and December (early summer) by merinos; in late December and January (midsummer) by crossbreds (Merino x Border Leicester); and in February and March (late summer and early autumn) by British Breed ewes (with the exception of the Dorset Horn).

The merinos were found to be in anoestrum or a very low state of sexual activity from July to October (late winter and spring) and the crossbreds from July to early December (late winter, spring and early summer). The full period of anoestrum of the British Breed ewes was not determined.

The earlier opening of the breeding season of merinos revealed by these findings, compared with those of Kelley (loc. cit.) in Eastern Australia, is pointed out.

In large groups of ewes of similar genetic origin the breeding season is shown to be made up of a series of peaks of intensity of oestrus incidence, recurring at regular intervals approximating the normal dioestrus period of 17 days.

Some suggestive evidence is presented that the presence of the ram may have an effect in bringing ewes into oestrus and a number of points of practical and scientific interest arising from the data are discussed.

ACKNOWLEDGMENT.

Grateful acknowledgment is made to Mr. W. A. Human, manager of the Avondale Research Station, for his careful help and interest in the oestrus incidence observations, and to Messrs. Langfield and Gishubl, of the Merredin and Chapman Research Stations, for assistance in the collection of the other data.

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Experiments with Serpentine Superphosphate and Phosphatic Guano as Fertilisers for the Wheat Crop.

L. J. H. TEAKLE, Plant Nutrition Officer and H. G. CARISS, Agricultural Adviser.

During the 1943 season, experiments were conducted at several centres in the wheat belt regarding the utilisation of Serpentine superphosphate from New Zealand and phosphatic guano from the Pelsart Island Group and are reported on in this paper.

I.—SERPENTINE SUPERPHOSPHATE.

Introduction.

In view of the reported advantages of Serpentine superphosphate as a fertiliser in New Zealand, the British Phosphate Commission made available one ton of the mixture early in 1943 for test in the field in Western Australia. This fertiliser is made by mixing three parts of hot semi-liquid superphosphate with one part of finely ground Serpentine—a soft rock, principally composed of magnesium silicate. The Serpentine reacts with the superphosphate, neutralising the acid, forming magnesium phosphate, and reducing the amount of water soluble phosphate in the fertiliser. The bulk of the water soluble phosphate of the original superphosphate is changed to the citrate soluble form.

The New Zealand workers claim a number of advantages from this fertiliser. The physical properties are undoubtedly improved and the damage to the bags is practically eliminated. On soils which are deficient in magnesium, some advantage may be derived from the magnesium content of the mixture and where certain micro-elements such as cobalt may be sub-optimal, the small amounts occurring as impurities in the Serpentine may be of some advantage.

The New Zealand Department of Agriculture claims that weight for weight, the Serpentine superphosphate mixture, which contains only three-quarters of the phosphate content of superphosphate, is equal in fertilising value to superphosphate. If this were so, it would mean that the quota of superphosphate available for the State could be increased by one-third if this material were incorporated in manufacturing.

The Experiments.

Two experiments with wheat for grain were arranged, one on the Wongan Hills Research Station and one on the Salmon Gums Research Station. Five treatments were used in each case in a randomised block layout using five replications.

The basal rate of superphosphate adopted was 56 lbs. of 22 per cent. superphosphate per acre in order to relate these experiments to the rate of superphosphate experiments already in progress. The rates of application were determined on the P_2O_5 basis. The fertilisers used were superphosphate, Serpentine superphosphate supplying three-quarters the amount of phosphate and an equivalent amount of phosphate and a mixture of superphosphate and soapstone supplying three-quarters of the equivalent of superphosphate.

History of Sites.

Salmon Gums Research Station.—The experimental site was on the sandy surface soils which have a calcareous sandy clay subsoil and are the most reliable of the district for wheatgrowing. The area had been under crop since 1928 and had received, prior to 1943, a total dressing of approximately 5 cwt. superphosphate per acre with five crops.

Rainfall data are:—

Year.	Jan.	Feb.	Mar.	Apl.	Growing Period. May.	June.	July.	Aug.	Sept.	Oct.	Total.	Nov.	Dec.	Total for Year.
1943	2	338	422	105	71	178	177	115	109	25	675	95	242	1,879
Average	99	78	163	92	126	143	144	156	90	121	780	95	83	1,397

Wongan Hills Research Station.—The soil types here are of the greyish sandy and gravelly heath country which has been under crop for about 15 years. Prior to 1943, the area had received approximately 4½ cwt. of superphosphate per acre.

Rainfall data are:—

Year.	Jan.	Feb.	Mar.	Apl.	Growing Period. May.	June.	July.	Aug.	Sept.	Oct.	Total.	Nov.	Dec.	Total for Year.
1943	107	142	153	84	98	314	121	201	136	42	912	....	26	1,424
Average	40	52	106	91	187	250	247	196	91	75	1,050	42	46	1,429

The Yields.

Details of the yields obtained are given in Table I. hereunder:—

TABLE I.

YIELDS OF WHEAT GROWN WITH SUPERPHOSPHATE, SERPENTINE SUPERPHOSPHATE AND SUPERPHOSPHATE AND SOAPSTONE.

	No Super.	68 lbs. 18% Super.	62 lbs. Serp. Super.	83 lbs. Serp. Super.	Super and Soapstone
22 per cent. superphosphate ...	0	56	42	56	42
Salmon Gums.—					
Yield—bushels per acre ...	12·2	14·6	13·4	14·6	14·6
Per cent. of 56 lbs. super. per acre	84	100	92	100	100
Wongan Hills.—					
Yield—bushels per acre ...	4·8	7·2	6·8	7·0	6·8
Per cent of 56 lbs. super. per acre	67	100	94	97	94

These data indicate that the yield is related to the amount of phosphoric acid supplied by the fertiliser and that the incorporation of the Serpentine has not improved the efficiency of the fertiliser. It should be noted that the yields from the Wongan Hills Research Station are unduly low owing to an attack of rust. This caused the grain to be shrivelled but it is considered that the yield differences accurately reflect the effect of the fertilisers used.

Conclusions.

Study of these data give rise to the following conclusions:—

1. Serpentine superphosphate, weight for weight, is inferior to superphosphate with respect to the yield of wheat for grain.

2. When the fertilisers are used on an equivalent phosphate basis, the Serpentine superphosphate and superphosphate appear to be approximately equal as far as yield of wheat is concerned.

The incorporation of Serpentine has not reduced the availability of the phosphate in the fertiliser.

3. There appears to be no justification for the incorporation of Serpentine or similar material in superphosphate under average Western Australian conditions as no apparent economy in the use of phosphate results. The availability of the phosphate is not improved and the increased bulk would involve much extra manpower, material, and transport.

APPENDIX.

Comparison of the analysis of Serpentine superphosphate and 22 per cent and 18 per cent. superphosphate.

Constituent.	Serpentine Superphosphate.	Superphosphate.	
		22 per cent.	18 per cent.
Water soluble P_2O_5	2·91	20·5	14·0
Citrate soluble P_2O_5	9·50	6·5	2·5
Acid soluble P_2O_5	2·44	1·0	1·5
Total P_2O_5	14·85	22·0	18·0

II.—PELSART ISLAND—PHOSPHATIC GUANO.

Introduction.

In May, 1943, the Government Mineralogist and Analyst, Mr. H. Bowley, drew attention to some samples of phosphatic rock and guano, which had been submitted to his laboratory for analysis. The residues of these samples constituted about 2 cwts., and after consultation with Mr. Dulfer, of the British Phosphate Commission, arrangements were made for the Department of Agriculture to carry out a number of experiments with wheat.

The object of the experiments was to obtain preliminary information regarding the fertiliser value of the Pelsart Island material as compared with superphosphate.

To this end, a composite sample was ground to pass a 50-mesh sieve and appropriate analysis carried out, prior to the material being used as a fertiliser.

Three experiments were arranged as follows:—

(1) Chapman Research Station.

(2) Messrs. Stokes Bros.' farm at Whelarra.

(3) Wongan Hills Research Station.

On the first two sites, the Pelsart Island material was compared with a similar quantity of 22 per cent. superphosphate. At the Wongan Hills Research Station, the treatments were extended to include a double dressing of the Pelsart Island material and a mixture consisting of one part of superphosphate and two parts of the Pelsart Island material.

The layout for (1) and (2) was the standard three plot system replicated five times, but at Wongan Hills, a 5 x 5 randomised block layout was utilised. Unfortunately, it was not possible to include as many treatments as desired, but those selected were considered to answer the main questions regarding the suitability of the material as a fertiliser for cereals.

History of the Sites.

1. *Chapman Research Station.*—The experiment was carried out on land which had been cleared for approximately 30 years and had received generous applications of superphosphate during this period. It is estimated that approximately 9½ cwts. of superphosphate have probably been used in the past.

2. *Stokes Bros., Whelarra.*—The soil is of a sandy loam type and the country originally carried York gum. The land was cleared 20 years ago, but has never received a great deal of superphosphate. The last crop was sown four years ago and no superphosphate has been used since that time.

3. *Wongan Hills Research Station.*—Greyish, sandy and gravelly heath country which has been under crop for about 15 years—approximately 4½ cwts. of superphosphate have been used with previous crops.

All three experimental sites were planted about the end of May on fallowed land under good conditions. Subsequent growth conditions were satisfactory, but rust affected the yields at Chapman and Wongan Hills, but all treatments appeared to be affected to a similar degree.

The rainfall recordings for the different sites were:—

Year.	Jan.	Feb.	Mar.	Apl.	Growing Period. May.	June.	July.	Aug.	Sept.	Oct.	Total.	Nov.	Dec.	Total for Year.
Chapman Research Station.														
1943	95	103	134	93	107	323	343	153	127	2	1,055	1	41	1,522
Average	29	39	70	74	234	419	383	266	150	89	1,553	35	26	1,817
Messrs. Stokes Bros., Whelarra.														
1943	2	....	11	158	305	296	145	142	115	66	1,069	....	43	1,283
Wongan Hills Research Station.														
1943	107	142	153	84	98	314	121	201	136	42	912	....	26	1,424
Average	40	52	106	91	187	250	247	196	91	75	1,050	42	46	1,429

The Yields.

The yields of wheat from the various treatments are summarised as follows:—

	Yield.	
	Bushels per acre.	Per cent. of Control.
Chapman Research Station.		
1. No fertiliser...	10·5	95
2. 22 per cent. Superphosphate at 40 lbs. per acre	11·0	100
3. Pelsart Island Phosphatic guano at 40 lbs. per acre ...	10·5	95
Stokes Bros., Whelarra.		
1. No fertiliser...	12·4	84
2. 22 per cent. Superphosphate at 46 lbs. per acre	14·7	100
3. Pelsart Island Phosphatic guano at 45 lbs. per acre ...	12·9	88
*Wongan Hills Research Station.**		
1. No fertiliser	6·0	67
2. 18 per cent. Superphosphate at 40 lbs. per acre	9·0	100
3. Pelsart Island Phosphatic guano at 40 lbs. per acre ...	6·6	72
4. Pelsart Island Phosphatic guano at 38 lbs. per acre ...	7·2	80
5. 20 lbs. Superphosphate and 40 lbs. Pelsart Island guano per acre	7·9	88

* Difference for significance P = ·05 = ·6 bushels per acre.

Conclusions.

Perusal of the results indicates that with the treatments, nil, 40 lb. superphosphate and 40 lb. phosphatic guano, that the effect of the phosphatic guano on the wheat yield has been negligible at Chapman, insignificant at Whelarra, and of doubtful significance at Wongan Hills.

The differences recorded between the different rates of Pelsart Island guano are estimated as of doubtful significance, but the 80 lbs. per acre appears substantially better than no fertiliser. Very large dressings, at least several cwts. per acre, of the guano would be necessary to give a response equal to the optimum amount of superphosphate of say 1 cwt. per acre.

Even when mixed with a small amount of superphosphate to provide water soluble phosphate to establish the seedling, the effect of the phosphatic guano is very small if not negligible.

It would be uneconomical to use phosphatic guano as a fertiliser for cereals without conversion into superphosphate. At best, the phosphate of untreated guano may approach 20 per cent. of the effectiveness of the phosphate of superphosphate.

APPENDIX A.

SIZING TEST OF PELSART GUANO FOR THE PLANT NUTRITION OFFICER, DEPARTMENT OF AGRICULTURE.

Description.—Bulk sample—50 mesh commercial screen used in field trials. Lab. No. 2668/43.

Sizing Test.

I.M.M. Screen	+ %	— %
20	nil	100
30	nil	100
60	24	76
70	28	72
80	34·5	65·5
90	37	63
100	38	62
120	43	57
200	57	43

APPENDIX B.

ANALYSIS OF COMPOSITE SAMPLE OF PELSART ISLAND PHOSPHATIC GUANO.

Constituent.	Composite sample Phosphatic Guano.		1 part 18% Super. and 2 parts Phosphatic Guano.		Superphosphate.	
	As received.	Moisture free.	As received.	Moisture free.	18 per cent.	22 per cent.
	%	%	%	%	%	%
Moisture	6·10	...	6·00	...	...	...
Nitrogen (N)	·819	·87	·546	·58	...	...
Water Soluble P_2O_5 ...	·02	·02	3·19	3·4	14·0	20·5
Citrate Soluble P_2O_5 ...	7·79	8·3	7·79	8·3	2·5	0·5
Acid Soluble P_2O_5 ...	13·25	14·1	9·46	10·0	1·5	1·0
Total P_2O_5	21·05	22·4	20·44	21·7	18·0	22·0
Total P_2O_5 as tricalcic phosphate (P_2O_5 × 2·18)	45·9	48·8	44·6	46·9	39·2	48·0

The Eradication of Black Spot or Apple Scab in Western Australia.

H. R. POWELL, Superintendent of Horticulture. and W. P. CASS SMITH, Plant Pathologist.

INTRODUCTION.

Black spot or scab is generally regarded as the most serious of all apple diseases. It is dreaded because it reduces crop yields and quality, and because the necessary control measures are very costly.

The disease appears to be present in all apple growing countries of the world, with the exception of Western Australia, *which is now believed to be free of black spot.*

This has not always been the case, however. Outbreaks have occurred here from time to time, and only the most strenuous efforts have prevented the disease from becoming as firmly established as the closely related black spot of pears.

The latest outbreaks occurred in the season 1939-40, and these were more serious than any of the previous ones.

Extent of the Outbreak.

The first outbreak of these series was reported from the Manjimup district in November, 1939. Mr. A. Fontanini, whose orchard was previously infected, discovered the disease whilst hoeing his trees. He immediately contacted the District Officer and from specimens submitted to the Plant Pathologist the disease was confirmed as Apple Scab. The work of picking and destroying the infected leaves was commenced immediately. Shortly afterwards, a survey was made by the Superintendent of Horticulture and the Plant Pathologist and full eradication measures were devised and instituted. These included spraying the orchard with Bordeaux Mixture and the picking and destruction of infected leaves and fruits. The disease, which first appeared in a mild form, later increased in intensity and spread throughout a considerable portion of the orchard. An adjacent orchard, after a close inspection, was also found to be infected and similar eradication measures were imposed.

During the measurements of apple and pear crops in January of 1940, two further orchards were found to be infected. One of these was situated in the Kalgan River district and the other at Jardee, near Manjimup. As there was a possibility that other orchards might be infected, additional Horticultural Officers were stationed in the Albany and Manjimup districts. A very close survey of these districts was made with the result that 21 orchards in the Manjimup district and three in the Albany district were found to be infected. The majority of the infections, however, were of a very slight nature, and in some orchards it was confined to single trees. Wherever possible infected material was stripped from the trees and destroyed by burning.

The outbreaks in the Kalgan River district were confined to three orchards in very close proximity. In the Manjimup district the disease followed a karri timber zone. This zone (number of infected orchards is in parentheses) embraced the Seven Day Road (11); Jardee (5); Graphite Road (1); near Manjimup township on the main Nornalup Road (1); Deeside Road (2) and Dean Mill Road (1).

The infected areas extended mainly in both a south-westerly direction and a south-easterly direction from the Manjimup township. One infected orchard was situated a few miles north-west of the township.

Eradication Measures Used.

The following were the main measures adopted in successfully eradicating the 1939-40 outbreaks:—

A. *At the Time of the Discovery.*

1. All visibly infected fruit and leaves were stripped from the trees and destroyed.

2. All trees in the infected area and the ground beneath were sprayed forthwith with home-made Bordeaux mixture 6 : 6 : 40 strength, plus spreader, and as an added safeguard against the spread of the disease, a buffer area around the infected trees was also sprayed with home-made Bordeaux mixture 3 : 5 : 50 strength, plus a spreader.

B. *Subsequent Measures.*

3. After the fruit of each variety was picked as it became mature, the trees of each variety throughout the whole orchard and the ground beneath were sprayed with home-made Bordeaux mixture 6 : 6 : 50 strength, plus spreader. No apples were sent away from the orchard either for sale or gift without first obtaining permission from an inspector, and then only to destinations approved by him.

4. Early in April, a quick-growing cover crop was shallowly sown throughout the whole orchard, so that the diseased leaves were prevented from blowing after leaf fall onto still uninfected parts of the same orchard or to other healthy orchards.

In August or early September (but as least a fortnight before spur burst commenced) the cover crop was deeply ploughed under, in one direction only, and subsequent cultivation was delayed until approved and then limited to very light harrowing.*

5. In spring all apple trees in the orchard were sprayed according to the following schedule:—

(a) At "spur burst" when the tips of the young leaves were showing, home-made Bordeaux mixture 5 : 4 : 50, plus spreader.

(b) At the "pinking" stage of blossoming when the majority of blossoms were showing pink, but before the petals had opened out, home-made Bordeaux mixture 3: 4 : 50, plus spreader.

(c) At the "petal fall" stage, home-made Bordeaux mixture 2 : 5 : 50, plus spreader.

(*Spreaders.*—In all sprays referred to calcium caseinate at the rate of 1 lb : 50 gallons of spray was recommended, but flour at the rate of 1 lb. : 50 gallons, or skim milk, 1 gallon : 50 gallons were also used. See Leaflet 314.)

Owing to the great difficulty of detecting the disease when present in slight amounts only, and in the light of experience gained in previous outbreaks, the measures listed under B. above, were yearly enforced until each infected orchard had remained visibly free of the disease for two full growing seasons.

At the present time, twenty out of the twenty-three orchards originally infected have remained visibly free of the disease for four full seasons, and the remainder for three. There is every justification, therefore, for the presumption that apple scab has once more been eradicated in Western Australia.

Eradication.

As mentioned earlier, wherever possible all infected material was stripped from the trees and destroyed by burning. In addition the infected areas were sprayed with Bordeaux mixture. The majority of the outbreaks were discovered late into the summer of 1940, and premature leaf fall owing to the very dry growing season experienced, made it impossible to arrange for the autumn sprayings with Bordeaux mixture to be applied in every infected orchard.

The real work of eradication commenced during the following August when instructions were given to the growers concerned that it was necessary for the ploughings to be in one direction only and that all areas unploughed were to be gone over by hand for the purpose of burying all apple leaves. Theoretically, if all the leaves previously infected could be kept under the ground, re-infection could not take place. Great difficulties were experienced in the Manjimup district in getting the leaves turned under for the reason that the majority of small growers

*The Black Spot fungus is carried over from one season to the next in the diseased leaves which fall to the orchard floor, and during the winter months it forms fruiting bodies known as Perithecia. At about the "spur burst" period in the spring the fruiting bodies commence to burst after showers of rain and fungal spores or seeds are ejected from them into the air with considerable force. This process of spore ejection may continue after rain for several week or more after bud burst has started. If the spores lodge on the young apple leaves, blossoms or fruits, they germinate in moisture and again bring about the disease. In order to prevent the disease recurring during the spring, the leaves were buried deeply just before "spur burst" and left undisturbed until they had completely rotted. Cross ploughing or deep cultivation, if done too early, will bring the leaves up to the surface before the rotting is complete and before the fungal seeds contained therein are harmlessly dispersed under the soil, allowing infection to occur. The spring spraying schedule is designed to further prevent primary infections arising from infected over-wintering leaves which have escaped burial. (See leaflet No. 306 for fuller information.)

concerned had neither the necessary equipment nor the knowledge to carry these instructions into effect. Two district officers were stationed in the Manjimup district to advise growers on the correct method of ploughing the leaves under. No great difficulties were experienced in the Albany district as the three growers concerned had the necessary knowledge and equipment. One of the real difficulties of this work was that owing to the premature leaf fall the previous autumn, many leaves had not been caught in the cover crops, as these had hardly made any growth, but had congregated along fences and in uncleared areas either adjacent to or included in most orchards.

Fig 1.—Owing to premature leaf fall, apple leaves congregated against logs and bracken fern cover. District Officers Flintoff and Herlihy are seen here slashing the fern preparatory to burning the area with the flame-thrower. (Orig. photo.)

As it was considered that the work of eradication rested primarily on the destruction of the old leaves, two flame throwers were secured. One was used in the Kalgan River district and the other in the Manjimup district. By the use of these flame throwers large quantities of apple leaves that could not be ploughed under, were destroyed.

Fig 2.—The flame-thrower in operation. District Officers Herlihy and Flintoff are destroying apple leaves caught in the bracken fern. An infected orchard lies in the background. (Orig. photo.)

During the third week of September sprayings with Bordeaux mixture commenced and various strengths were used depending on the stage of the trees—whether at spur-burst, pinking or petal-fall stages. In order to advise the growers,

particularly in the Manjimup district, of the correct methods of preparing Bordeaux mixture and its application to the trees, the Plant Pathologist visited the district and three officers were stationed there. As some of the smaller growers did not possess spraying equipment a hand-operated departmental outfit was made available. In many cases this outfit was worked by district officers over week-ends to enable the sprays to be applied at the correct times.

Fig 3.—The Departmental "Everlasting" spray pump was used consistently. In the foreground District Officers Miller and Herlihy are spraying an infected orchard. The owner of the orchard, Mr. J. Dick, is in the background. Few apple leaves are on the surface of the ground. Delayed cultivation, with the exception of light harrowing, until January will do much to prevent re-infection.

(Orig. photo.)

All the sprays were applied in the Kalgan River district on schedule, as the growers concerned possessed power operated spraying outfits.

In addition to the orchards that were found to be infected, orchards in the immediate vicinity were also compelled to apply the eradication measures. Two orchards at Manjimup and seven in the Kalgan River district were concerned. In all, 278 acres of infected orchards and 193 acres of non-infected orchards were sprayed three times. The total area sprayed was 471 acres.

Unfortunately, the Bordeaux mixture caused extensive russeting of the fruit. The varieties most affected were Cleopatras, Dunns and Granny Smiths. The coloured varieties were not so adversely affected.

During the early summer of 1940 a very close inspection was made of every orchard that was infected the previous season. As a result a slight carry over of the disease was found in three orchards only in the Manjimup district. As a safeguard against the occurrence of unknown infection centres, and to discover any possible spread of the disease, weather vane spore traps were constructed by the Plant Pathologist and installed in these three orchards, and the slides were microscopically examined at fortnightly intervals. Throughout the growing season of 1940-41, careful inspections continued at regular intervals, but no further traces of the disease were discovered. Before leaf fall commenced, the orchards previously sprayed with Bordeaux mixture were again sprayed.

During August of 1941 serious labour shortages threatened to prevent the satisfactory burial of leaves in the Manjimup district. Enlistments in the Armed Services had been heavy from this district, and other important local industries

such as the flax, dairying, tobacco and timber were extremely short of man-power. The position was met by the wholehearted support from other fruit-growers, who generously supplied the labour to enable this, a most important phase of the eradication campaign, to be satisfactorily completed.

During the latter part of September and early October, all orchards previously infected and those adjacent to infected orchards, were compelled to spray with Bordeaux mixture. Two Horticultural Officers were stationed at Manjimup to assist the local District Officer in supervising this work. Owing to the extreme shortage of labour many growers could make no satisfactory arrangements to have their orchards sprayed. Fortunately due to the co-operation of Messrs. C. and A. E. Blakers a power operated spraying outfit was made available to spray the majority of the affected orchards. Three men from the Department of Employment were also made available to operate the departmental spray pump in the outlying areas where the power outfit could not conveniently work.

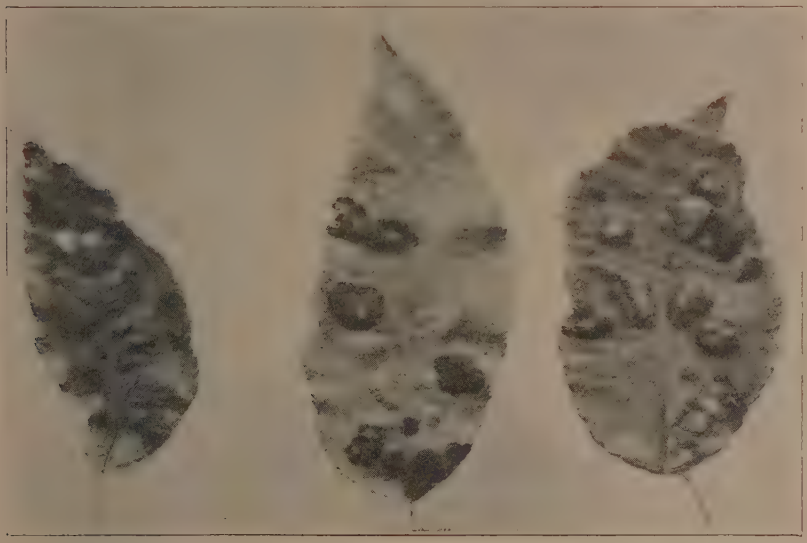

Fig 4.—"Black Spot" or "Scab" on apple leaves from Upper Kalgan, January, 1940. During enlargement the localised lesions frequently become upraised, presenting a blistered appearance, the opposite surface becoming correspondingly depressed. Lesions of this kind were abundantly present in all the affected orchards this season. Note distortion of the leaves at left and right. Lesions rather similar in appearance to the above caused by the closely related Pear Scab fungus are often seen on pear leaves in W.A.

It was the earnest wish of all concerned, that the disease would not show up during the 1941-42 growing season. This was realised as repeated inspections revealed no trace of the disease in either the Manjimup or Albany districts.

Although the success appeared to have been achieved, the eradication measures including the autumn application of Bordeaux mixture and leaf burial, were again insisted upon.

As no signs of the disease had been found in the Albany district since the growing season of 1939-40, no further compulsory eradication measures were required to be carried out during the 1942-43 growing season. With the exception of the three orchards where a carry-over of the disease was noticed during 1940-41,

the same course of action was adopted in the Manjimup district. Certain voluntary safeguards, however, were carried out by the growers concerned. However, as an additional safeguard a careful inspection was made by Plant Pathological officers in the autumn of 1943. As no trace of the disease could be found, and as the orchards had remained visibly healthy for three full growing seasons, the growers were released from all further restrictions.

Eradication measures for the 1942-43 growing season were confined to three Manjimup orchards. The full spraying schedule was satisfactorily completed, despite difficulties caused by extreme labour shortages.

Repeated inspections were made during the season, not only of these orchards, but of all that had been previously infected, without finding any trace of the disease. What had appeared the impossible had been achieved.

Although all the growers concerned suffered financially some measure of real assistance was provided by the West Australian Fruit Growers' Association, who made available a grant of £500 to recoup the costs of the spraying materials used.

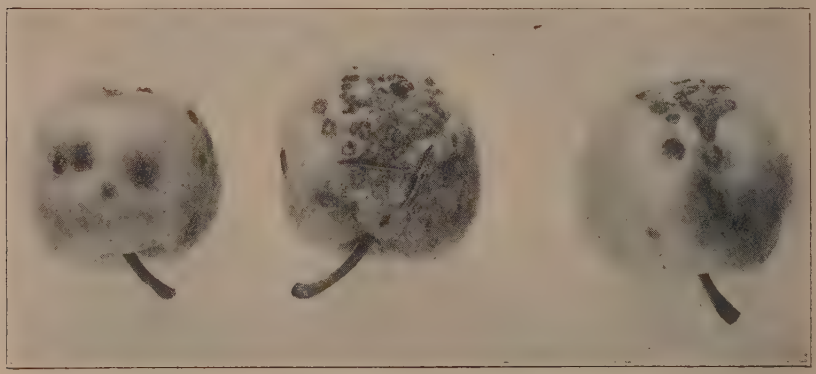

Fig 5.—"Cleopatra" apples from Upper Kalgan, January, 1940. Affected with "Black Spot" or "Scab." Note the distortion of all fruits and the cracks in the centre apple.

In addition, the Association met the cost of one-quarter of the estimated losses caused by spray russet, which generally reduced the quality of the fruit from fancy to good grade during the 1940-41 season. In early 1942 the Fruit Growing Industry Trust Fund Act came into operation and growers have been recouped from the Trust Fund with the cost of the spraying materials used and one-third of the estimated losses caused by russeting during each of the seasons 1941-42 and 1942-43.

Throughout the period of eradication, the Department has received the greatest co-operation from the growers concerned, even when it appeared that their own immediate prospects were being sacrificed without the security that the disease would be eradicated. Real difficulties have been met and surmounted, and it is sincerely hoped that no further outbreaks will take place.

Value to the Industry.

Though the cost of eradication has been serious, much greater losses would undoubtedly be incurred had the disease not been eradicated. It is estimated that if the disease became widespread throughout Western Australia the cost of the

sprayings alone would be in the region of £65,000 per annum. This figure does not include the losses that would be caused by fruit destroyed and rejected on account of Apple Scab blemishes.

Danger of Future Outbreaks.

The Department has now substantial evidence that some earlier outbreaks originated from diseased leaves attached to young imported apple trees. In May, 1937, the disease was found on the leaves of young imported apple trees carried over in an Albany nursery from the previous winter.

Also, in the winter of 1937, leaves infected with apple scab were found at local ports of entry in a number of consignments of young trees from the Eastern States.

This avenue of introduction has now been adequately safeguarded by the following precautions which have operated during and since the winter of 1937.

"All apple and pear trees imported into Western Australia are now dipped or sprayed with Bordeaux mixture before leaving the inspection sheds at Fremantle and Albany. Consignors of apple trees to this State are required to remove all leaves before despatch, and should any trees be found infected with the disease at local ports of entry the consignor is given the option of having them destroyed here or returned to him."

It seems probably, therefore, that if in future an outbreak of apple scab occurs in W.A., it will be caused by the introduction of apple fruits, contrary to regulations, infected with the disease.

Legislation exists which totally prohibits the entry of apples and other pome fruits into this State, but unfortunately this is not always observed. Within recent months a parcel of apples from an eastern State of Australia was confiscated at the Perth G.P.O. and upon examination, *live Codlin Moth grubs* were found in some of the fruits. In all probability, the person forwarding the parcel broke the law quite unwittingly and was sublimely unconscious of the fact that the apples might seriously jeopardise the apple-growing industry in Western Australia.

Conclusion.

If, despite all precautions, a further outbreak of apple scab should occur here, it is the firm conviction of the writers, in the light of past experience, that it can also be eradicated provided—

(i) The Department becomes aware of the outbreak at an early stage in its development.

(ii) The correct control measures are properly applied.

To meet proviso (i), all apple growers should be familiar with the symptoms of the apple scab disease (see figs. 4 and 5) and should forward to the Department any specimens showing suspicious symptoms immediately they are noticed.

Regarding (ii), it should constantly be borne in mind that the owners of infected orchards suffer considerable financial loss both from the enforced application of costly control measures, and from the reduction in yield and quality of fruit, and also that in combating the disease they are safeguarding the interests of all other apple growers, besides their own.

Dairy Sanitation.

C. W. TOBIN, Dairy Instructor.

The importance of dairy sanitation is sometimes overlooked by dairy farmers. In some cases it is not fully understood, yet, each year large quantities of milk and cream are contaminated by unsanitary conditions which are quite within the means of the ordinary farmer to remedy. The approach of another flush season for the dairy industry is an appropriate time to write a few notes on this subject, and may serve in bringing farmers' attention to their own dairies to check up on any neglect likely to lead to faulty sanitation.

Milking Shed.

The milking shed should be erected on a site on rising ground at least 200 feet from pig sties, and the foundation should be built up sufficiently to permit adequate fall for drainage. It should be constructed of durable materials such as wood, iron, or concrete. Asbestos sheets can be used on the upper portion of the building where they will be out of reach of receiving a severe knock likely to break the asbestos.

The roof should be a clear seven feet above the floor at the lowest part and the roofing material should be weatherproof.

Ventilation should be such as to allow a plentiful flow of air and natural light. The open front type of shed has an advantage in this respect.

The floor is an important part of a milking shed and should be constructed of material impervious to moisture, on a solid foundation. It should be evenly graded with proper slopes directed opposite to the feeding trough, to an open drain the whole length of the shed. The open drain should be extended to at least 20 feet from the shed, and be of sufficient width as to permit of being readily cleansed with a broom. Flooring material recommended is a concrete foundation with a moderately smooth cement finish.

Cracks and holes in floors are the enemies of sanitation, and should be promptly and efficiently repaired.

The finishing off of the interior of a shed with a coat of good white-wash or white paint, with a 3ft. tarred strip around the bottom of the walls and posts, is desirable.

Water Supply.

The provision of an adequate water supply at the dairy or milking shed is an essential of sanitation very often neglected. A plentiful supply of water, free from excessive contamination and undesirable germ life is an absolute necessity to the production of clean milk and cream.

In the heavier rainfall areas of the State, shed catchment can usually provide tanks with sufficient to supply needs during summer months. One or two 2,000 gallon tanks full at the end of the winter will go a long way towards meeting the normal shed requirements of a 20 to 30 cow dairy, providing stock drinking supplies are not drawn from the tanks.

The erection of a 6,000 or 8,000 gallon concrete tank, partly underground, adjoining the milking shed, is an economically constructed reservoir to be recommended. Also, divining for underground water near milking sheds has revealed surprises as to the low cost of obtaining ample supplies, and is worth consideration by farmers in need of water.

Hot Water Supply.

Very often, what appear to be the "not so important" things and are neglected by a farmer, are the "most important" in respect to sanitation. Means of providing *adequate boiling water* for the washing of machines and utensils is another necessity to the clean production of milk and cream, without which a farmer should not expect to obtain good returns for his product.

A 10 or 14 gallon copper, preferably bricked in, or a dairy type steam boiler convenient to the milking shed is a requirement of every dairy.

Milking Machines.

The recommended method of cleansing milking machines is set out in an article which appeared in this Journal in September, 1933. This article has been reprinted in leaflet form and copies are available at the Department of Agriculture, Perth, free on request.

Separator and Utensils.

The rinsing of separator parts and utensils in cold or luke warm water immediately after use is necessary to prevent the formation of a coating of milk stone on surfaces in contact with milk. This milk stone, if permitted to adhere will harden and become very difficult to remove.

After rinsing, all parts should then be washed and scrubbed with scalding water using washing soda or some other washing compound which will soften the water, emulsify the fats, and permit the solution to remove any deposit from the utensil surfaces. This should be then followed by the immersion of all parts and utensils in boiling water, to wash away the residue of the washing compound, effect sterilisation, and impart sufficient heat as will enable them to become completely dry in a very few minutes.

Other Details.

In addition to the above there are several other points requiring constant care and attention of the farmer to assure the sanitary production of milk and cream. Some of these include:—

(1) The frequent removal of dung from the immediate vicinity of the milking shed.

(2) The washing of cows' udders prior to each milking, preferably using a few grains of potassium permanganate (Condy's crystals) in the water.

(3) The personal health and cleanliness of persons attending cows in the milking shed.

REFERENCES.

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Cullity, M., 1933: The Cleansing of Milking Machines, *Jour Agric., W. Aust.*, 10 (3), (*Second Series*), page 385.

Emus.

Emus appear from time to time in considerable numbers and do extensive damage to crops on holdings situated on the fringe of settlements. They are creatures that come and go according to the seasonal conditions. They mostly come from the northern pastoral areas each good season. Northwards the herds are inclined to remain, but with dry times they come southwards towards the wetter areas and appear in numbers on the fringe of the farming districts, usually during October. During these migrations the pest congregates in thousands during the exceptionally dry seasons along the rabbit-proof fences and travels along them seeking water. Hundreds perish in this movement, but it is astounding the distances emus, half famished, will travel when seeking water. On reaching settlements they generally halt but some are driven in by moving vehicles and do not appear to be able to find their way out again because of the fences, etc. The majority, however, remain on the edge of the farming areas and travel around the outskirts of the district and then on into the adjoining districts, and so on. This is clearly indicated in the various drives which have taken place, very few being obtained in the settled areas whilst flocks were seen and met with on the outskirts.

The inspectors on the rabbit proof fences account for great numbers whilst travelling in the course of their work, and one advises that with the last 100 rounds of 12 gauge ammunition he shot 289 birds.

In the Wyalkatchem district, drives organised by the Board were credited with the destruction of large numbers of emus. The method employed was the use of about half a dozen trucks each carrying three or four men with shot guns. When the emus were sighted, the fastest of the vehicles endeavoured to get between the mob and the timber or scrub cover, keeping them within range of the others from which they were shot. Sometimes they escaped, but by adopting these means some 1,800 were accounted for.

Many settlers maintain that emus breed in their districts because they see such a number of half-grown birds. They forget or fail to realise the distances these birds can travel for water. A drive a few weeks ago might have yielded results, but if another drive were held now, since the rains, it is likely that very few would be found, the majority having migrated, and if there are no good rains northwards the birds will return again about October.

When in numbers, the shot gun is the best weapon with which to deal with them. One shot from both barrels has accounted for 26. When in two or threes and a bit wild as the usually are when herded on an enclosed holding, the rifle is almost essential.

Poisoning of waters in the dry portion of the year yields success, as does also the laying of poisoned baits around waters during the same period. Heads of wheat poisoned with phosphorous rabbit poison together with ordinary phosphorised pollard such as is used for rabbits, has yielded success; 80 were poisoned in this way around a water hole, and incidentally, two horses were also poisoned, so care needs to be exercised and stock kept away from such spots.

An excellent opportunity was offered this summer to deal effectively with those birds that congregated near water in the settled areas. Most of the surface waters dried up and only a few dams had water in them. Some good kills were recorded but it is to be regretted that shortage of manpower generally did not permit of a clean sweep being made at this time.

Copper Sulphate (Bluestone) Supplies.

Judging by the number of enquiries received by correspondence and through field officers of the Department, the supply position of copper sulphate for top-dressing has been causing no little concern among farmers, particularly those from the districts known to be deficient in copper or where increased yields have been obtained as a result of using dressings containing this element.

Investigation of the copper position on an Australia-wide basis has revealed that, like many other commodities during wartime, copper sulphate is in short supply, and in order to ensure, as far as possible, that the best use is made of the limited quantity available, control measures have been taken over its distribution.

It was decided that the most urgent need was felt by farmers requiring copper sulphate for the preparation of stock licks and the treatment of foot-rot, and supplies for these two purposes were made a first charge against the stocks available.

Following these allocations, consideration was given to the requirements for top-dressing, and as it became apparent that there would be insufficient to fill all orders received, it was further decided to limit the release of copper-bearing fertiliser to the districts of Albany-Denmark-Walpole, Dandarragan, Gingin, Manjimup, Margaret River and Northcliffe. Of supplies available, 15 tons were allocated for the preparation of stock licks, and the remainder of the amount available for agriculture needs generally was made up into bluestone-superphosphate mixture.

Messrs. Cuming Smith-Mt. Lyell Farmers' Fertilisers had 280 tons of this mixture available at Picton during May for distribution in the lower South-West and of this, orders were held for 134 tons required in the nominated areas. This left 146 tons for future orders from nominated areas and other districts.

The supply position with respect to bluestone over the last few years is interesting. The imports into Western Australia in the last six years have been: –

1938	.. ..	167 tons.
1939	.. ..	365 „
1940	.. ..	383 „
1941	.. ..	360 „
1942	.. ..	361 „
1943	.. ..	442 „

This huge growth in the shipments to Western Australia results from the use of bluestone as a fertiliser for crops in this State. Had the full requirements been met in 1943, at least 200 tons more than that actually received would have been required.

For the 1943-44 season, imports at Fremantle have totalled 378 tons 17 cwts. and at Albany 28 tons, bringing the total to 406 tons 17 cwts. Orders held at the present time by Eastern States suppliers on behalf of Western Australian firms are known to amount to 550 tons. Every endeavour is being made to arrange for these orders to be met either from Australian or outside sources.

From the foregoing, it should be obvious that this Department and the importers are doing all that is possible to ensure abundant supplies for the coming year. We have been informed, however, by the Director General of Agriculture that of the Australian production of slightly over 2,000 tons of copper sulphate per annum, we are at present receiving 440 tons which is somewhat in excess of 20 per cent. of the total Australian production. We understand that the prospects for increasing the allocation to this State are not bright; but efforts are being made to procure additional supplies from overseas.

Further Results of Experiments at the Agricultural Research Stations with the Phosphate Requirements of the Wheat Crop.

H. G. CARISS, Agricultural Adviser.
L. J. H. TEAKLE, Plant Nutrition Officer.

During the 1943-44 season experiments covering the effects of varying rates of phosphatic fertilisers on the growth of the wheat crop were continued. The results obtained were similar to and confirm the findings of previous years' results fully reported on by Teakle and Cariss, March, 1943.*

The experiments conducted were:—

Rate of superphosphate (1929 series).
Rate of superphosphate (1941 series).
Rate of superphosphate (1943 series).

THE EXPERIMENTS.

1929 *Series.*

The results for 1943 of the 1929 series experiments are embodied in Table I., together with the average over the period. Owing to no site being available, plots in this series were not planted at the Merredin Research Station. At Wongan Hills, a small yield was again obtained from the no super plots. These plots had received no previous dressing of superphosphate since the paddock was first cultivated and for the first three crops no yields were obtained. The small yields obtained are due to side effect such as wind blowing and cultivation from adjacent plots.

The actual computed yields per acre were affected by seasonal conditions and disease, particularly at Wongan Hills, but the percentage results are considered reliable, and are practically identical with those obtained in previous years on the same plots, as shown in Table II. As with the results for previous years, Chapman Research Station shows little response to superphosphate, the land appearing to have been substantially built up in phosphate by previous dressings of super. The response to superphosphate is the greatest at Wongan Hills. At Salmon Gums, while there has always been a substantial positive response, the degree of response has shown considerable variation over the period with the no super plots yielding as well in 1943 as they did in 1930

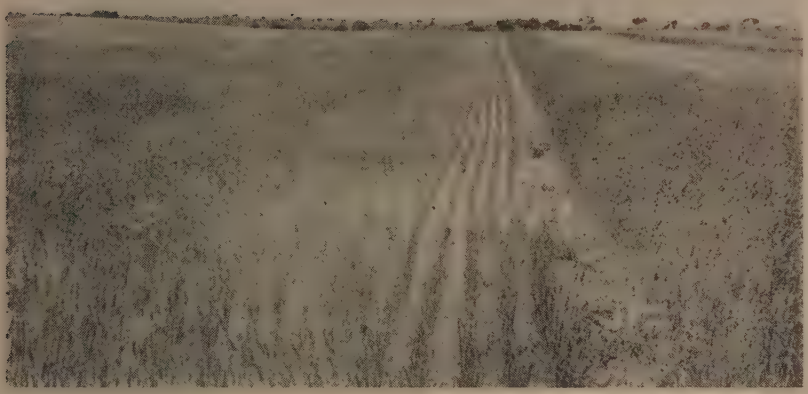
1941 *Series.*

In the 1941 series at Merredin and Wongan Hills the sites planted in 1941 for the first time were again sown with the same treatments in 1943. At Merredin, though all plot yields per acre were higher than for the previous year (1941) the yields of the no fertiliser plots relative to the other treatments were lower; at Wongan Hills the plots, in addition to being affected by rust, were otherwise damaged and the results cannot, therefore, be treated as reliable.

*Teakle, L. J. H. and Cariss, H. G., Jour. Agric., West. Aust. 20 (2nd series) 1-28.

In addition to the repetition of sowings on these sites, further new plots were planted at the Chapman, Merredin, Salmon Gums and Wongan Hills Research Stations. Details of the yields of all the plots in this series are contained in Table III. In Table IV., the comparison between the first year plots for the 1929 series and the 1941 series is shown. In Table V. the yields of successive crops on the same plots and with the same phosphate treatment are given similarly to Table II.

WONGAN HILLS RESEARCH STATION.
Rate of Superphosphate Experiment (1929 Series).
Season 1943-44. Paddock 2E.



75 lb. per acre. No fertiliser. 150 lb. per acre.
11.6 bus. per acre. 1.7 bus. per acre. 17.7 bus. per acre.
The no fertiliser plot illustrated above has received no direct application of superphosphate since the land was first cleared in 1928. Note the cape weed in fertilised plots as compared with the no fertiliser plot.

With regard to the new sites planted for the first time in 1943, the Wongan Hills results are again unreliable owing to disease effect, but those at Chapman and Merredin are of particular interest. At Chapman, one of the new experimental sites was on fallowed land which had received approximately 10 cwt. of super per acre with previous crops and the other on unfallowed land which had been out to improved pasture continuously for the previous seven years in six of which the area had received 1 cwt. of super per acre, bringing the total to at least 15 cwt. in all over the period 1912-1943. This site probably received 2-3 cwt. more during the period 1903-1911. The results obtained are a further indication of the high degree of phosphate saturation of the soils on the Station. Rust affected the yields from both sets of plots.

At Merredin, one set of the new plots was situated in the oldest cultivated paddock on the farm which had received, at least 12 cwt. super per acre previously. The results for this site were practically identical with those from the first plantings in the 1941 series in paddocks 3, 5 and 8 which had received

approximately 12, 10 and 8 cwt. of super per acre respectively, previous to the planting of the experiment. On the other site, which was in a paddock which had received barely 5 cwt. per acre in the past, the percentage yield of the no fertiliser plots as compared with the 56 and 112 lb. treatments was, at 72 per cent., considerably less than that obtained on the other sites which had been more generously treated in the past. It will be noted, however, that, as with the other sites, there was no difference between the 56 and 112 lb. treatments

1943 *Series.*

An experiment embodying no fertiliser, 40 and 80 lb. of 18 per cent. super per acre treatments was also planted at the Merredin and Wongan Hills Research Stations. The details of results are given in Table VI. At Merredin, the reduction in yield from the low rates was of no practical significance and similar to the results obtained with the 1941 series. At Wongan Hills, as with the other experiments, the yields were affected by disease, but are similar to those obtained in the 1941 series in the same paddock.

Additional Experiments.—In addition to the above, experiments reported separately* were also conducted using Phosphatic Guano from the Pelsart Island Group and Serpentine Superphosphate from New Zealand and these experiments involved no fertiliser plots and plots receiving super only. A comparison of the results from all experiments shows a close agreement.

THE RATE OF SUPERPHOSPHATE AND CROP YIELD.

It has been contended that the reduction of the super dressing to 40 lb. per acre would result in at least halving the crop yields if not in actual crop failure. This is not borne out either by the experimental results or by the yields from the bulk cereal crops at the Research Stations. A comparison of the wheat yields up to 1941 and for the 1942 and 1943 seasons at the Research Stations (Table VII.) shows that with reduced dressing of superphosphate for the latter two years the crop yield has not been seriously affected, if at all. Perusal of the detailed results from the bulk crops as well as the experimental data, leaves no doubt that the yields on the Research Stations have been affected more by seasonal and other conditions, such as the incidence of disease, rather than by the reduced rate of application of superphosphate. Details of the comparisons are set out in Table VII.

The results of the experiments discussed above confirm the conclusions drawn from previous years' results and experiments, that, where liberal dressings of superphosphate have been applied in the past, reduction in crop yield with the present low rate of super available will be slight even on light soils. With light soils, the yields will be more affected by the level of previous dressings than with heavier soil types. With all types, cultural methods and seasonal conditions play a much greater part than is generally acknowledged. An application of super, though beneficial, is not an assurance that a satisfactory crop will result; more crop failures result from unsatisfactory seasonal conditions, disease, etc., than from low superphosphate dressings.

RECOMMENDATIONS.

Recommendations for cropping with small supplies of superphosphate which can be made from perusal of the experimental results, yields of bulk crops and general observations are—

* See page 143.

A. *During the period when the supply of super is short*:—

(1) Avoid cropping virgin land or land which, in the past, has received only small dressings of fertiliser.

(2) Spread available supplies over as large an area as possible; utilising the whole of the super ration over half the area will most certainly not return more produce than would have been obtained by spreading it over the whole area. In most cases, little more than half the produce would be obtained.

B. *When normal quantities of super are again available*:—

(1) On account of the importance of super for the growth of crops and the succeeding pastures it is recommended that up to 1 cwt. be applied on heavy and medium soils and up to 150 lb. on lighter soils.

(2) In the early years of cultivation, the dressings should be as heavy as is economic or within the financial ability of the farmer in order to build up the phosphate content of the soil to a satisfactory level as quickly as possible. This level appears to be of the order of ½ ton of super per acre, but the actual amount will be dependent on the nature of the soil.

(3) When the phosphate content has been built up to a certain level, smaller applications of superphosphate can be used with negligible reduction in yield, but little addition will be made to the reserves.

DISCUSSION.

With regard to the storing up of phosphate in the soil, it is of interest to recall that the phosphoric acid (P_2O_5) in the above ground portions of a 20 bushel wheat crop, ranges from 7.2 to 7.8 lb. depending on the grain straw ratio. This is equal to 33-35 lb. of 22 per cent. or 40-43 lb. of 18 per cent. super. Further, having regard to the fact that the State wheat average is approximately 12 bushels per acre and the average dressing of super was, according to statistical records, about 100 lb. per acre prior to the imposition of restrictions there would have been a net average gain for the State in the soil of 80lb. 22 per cent. super equivalent to approximately 17½ lb. P_2O_5. Over a period of years, there has been a considerable accumulation of phosphate which, though not in a readily available form like the water soluble fraction in super, would still be of use to the plant. The greater the degree to which the soil has been built up by previous dressings of super the more readily will the plant utilise this phosphate for its growth.

From perusal of all the experimental results (cf. also Table IV.) it will be noted that there is actually little or no difference in yield between the plots receiving 40, 56, 80, 112 or 150 lb. of superphosphate. This demonstrates that once the phosphate level of the soil has been built up to a satisfactory level with generous dressings of superphosphate, further accumulations from subsequent dressings have little immediate effect on crop yields and that relatively small applications of water soluble super at seeding are sufficient for optimum plant growth. The plant obtains its major phosphate requirements during the first six-eight weeks of growth by which time the remaining water soluble fraction has been reverted to less available forms. The balance of the plants' requirements are therefore obtained from the reverted and stored up phosphate in the few surface inches of cultivated soil. With small applications at seeding time, little or none is available for accumulation, the plant possibly having to draw on the stored up reserves for portion of its requirements. With heavier applications, larger amounts are available for building up the reserves and the higher the individual dressing the sooner will the phosphate level be raised to that degree where subsequent dressings appear to have little effect in increasing crop yields.

TABLE I.

RATE OF SUPERPHOSPHATE EXPERIMENT.
1929 SERIES.

Research Station.	Average Rainfall.		Yields per acre. Low Rate Group.						Yields per acre. High Rate Group.					
			Nil.		75 lb.		150 lb.		150 lb.		225 lb.		300 lb.	
	Growing Period May--Oct.	Annual.	Bus. per acre.	%	Bus. per acre.	%	Bus. per acre.	%	Bus. per acre.	%	Bus. per acre.	%	Bus. per acre.	%
Chapman—														
1943	1,055	1,522	8·2	93	9·2	105	8·8	100	7·8	100	7·8	100	8·1	104
Average 15 crops	1,555	1,825	11·4	82	13·1	96	13·7	100	13·6	100	13·6	100	14·0	103
Salmon Gums—														
1943	675	1,879	8·7	69	13·2	104	12·7	100	12·2	100	11·5	94	11·0	90
Average 15 crops	787	1,362	7·0	48	13·1	89	14·7	100	15·9	100	16·5	104	16·6	104
Wongan Hills—														
1943	912	1,424	1·2	10	9·0	72	12·4	100	10·6	100	10·4	97	11·2	105
Average 14 crops	1,060	1,429	4·0	20	16·4	82	17·0	100	19·5	100	20·2	103	20·3	104
*Merredin—														
Average 12 crops	807	1,193	13·1	60	20·2	93	21·8	100	22·3	100	22·9	103	23·2	104

* No plots planted in 1943.

TABLE II.

Yields of Successive Wheat Crops Grown on the Same Plots Without Superphosphate 1929-1943.

Year.	Rate of Superphosphate Application. Nil. Bus. acre.	75 Bus. acre.	150 Bus. acre.	Percentage of Yields of no super plots as compared with 75 lb./ac. %	150 lb./ac. %
CHAPMAN RESEARCH STATION.					
Paddock 21 (cleared 1914).					
Six previous crops—total superphosphate—500 lb. per acre.					
1929	8.1	9.7	11.3	84	72
1932	7.0	9.4	11.0	74	64
1934	5.6	6.6	7.4	85	76
1936	14.7	15.2	15.1	97	97
1941	11.8	12.1	13.6	98	87
1943	8.2	9.2	8.8	89	93
WONGAN HILLS RESEARCH STATION.					
Paddock 2E.					
No previous crops or fertiliser applications.					
1929	Nil.	5.9	8.7	—	—
1931	Nil.	10.6	15.8	—	—
1935	Nil.	17.5	25.0	—	—
1939	1.3	10.6	14.2	12	9
1943	1.2	9.0	12.4	12	10
SALMON GUMS RESEARCH STATION.					
Paddock B1.					
Cropped 1928—total superphosphate—90 lb. per acre.					
1930	8.2	12.7	13.9	65	59
1932	7.3	22.9	24.2	32	30
1934	2.8	9.4	12.5	30	22
1941* ..	5.8	11.2	12.5	52	46
1943	8.7	13.2	12.7	66	69

*Four plots only.

TABLE III.

Research Station.	Year.	Rainfall.		Paddock No.	Superphosphate applications since 1928.	Estimated Total previous superphosphate applications.	Rate of Superphosphate Applied lb. per acre.				
		Growing Period.	Total.				Nil.		56 lb.		112 lb.
					lb./ac.	lb./ac.	bus./ac.	%	bus./ac.	%	bus./ac.
Chapman	1942	1,527	1,783	19	448	1,374	14·2	104	14·0	103	13·6
	1943	1,055	1,522	21	560	1,060	8·7	90	10·2	104	9·8
	*1943	1,055	1,522	16	896	1,700	9·5	109	9·0	104	8·7
	Average	1,555	1,825	...	...	...	11·5	98	12·1	104	11·7
Wongan Hills	1941	1,077	1,532	1E	485	747	13·0	75	16·4	95	17·3
	1942	1,233	1,933	4H	270	270	12·0	65	17·4	95	18·2
	†1943	912	1,424	2E	515	515	5·0	41	9·6	79	12·2
	†1943	912	1,424	1E	485	747	4·7	90	5·0	96	5·2
	Average	1,060	1,429	...	...	...	9·9	60	14·5	91	15·9
Merredin	1941	1,020	1,271	8	374	970	26·9	96	28·8	103	28·1
	1942	840	1,464	5	336	1,060	24·6	90	27·7	101	27·4
	1942	840	1,464	3	672	1,350	16·8	91	18·4	100	18·4
	1943	913	1,862	1	672	1,335	28·4	91	31·2	100	31·2
	1943	913	1,862	6	224	534	19·2	72	26·4	99	26·7
	1943	913	1,862	8	374	970	27·9	80	32·9	95	34·1
	Average	811	1,214	...	...	...	23·2	88	26·5	101	26·4
Salmon Gums	1942	...	...	A3	448	738	12·2	77	15·4	97	16·0
	1943	675	1,879	B1	448	538	12·2	84	14·0	97	14·4
	Average	787	1,424	...	...	...	12·2	80	14·7	97	15·2

The average for each Station is that for the initial year on each site.

* Three plots only. † 1943 yields affected by severe rust.

TABLE IV.

ESTIMATED RELATIVE YIELDS OF WHEAT ON PLOTS RECEIVING NO SUPERPHOSPHATE FOR THE FIRST TIME IN THE 1929 SERIES AS COMPARED WITH THE 1941 SERIES.

Yields on plots receiving 75 lbs. of superphosphate per acre are adopted as controls.

Research Station.	Paddock.	Superphosphate applications.		Percentage Yields on "no superphosphate" plots as compared with 75 lbs. per acre plots.			
		Additional since commencement of 1929 series.	Estimated Total prior to commencement of 1941 series.	1929 series.		1941 series.	
				Year.	Per cent.	Year.	Per cent.
		lbs. per acre.	lbs. per acre.				
Chapman	6A	448	1,192	1931	78	....	....
	19	448	1,374	1930	98	1942	104
	21	560	1,060	1929	84	1943	84
	Average	....	....	. .	87	....	93
Wongan Hills	1E	485	747	1932	61	1941	77
	4H	120*	270	1938	37	1942	67
	2E	515	515	1929	....	1943	46
	Average	....	....	. .	33	....	63
Merredin	3	672	1,350	1929	80	1942	90
	5	336	1,060	1931	72	1942	88
	8	374	970	1930	51	1941	92
	Average	....	. .	. .	68	....	90
Salmon Gums	A1	....	....	1929	35	....	.
	A3	448	538	1936	54	1942	78
	B1	448	538	1930	65	1943	85
	Average	....	. .	.	51	....	78

* In 1938 which was the first year of the 1929 series in this paddock. No subsequent additions were made.

TABLE V.

Yields of Successive Wheat Crops Grown on the same Plots without Superphosphate 1941-1943.

MERREDIN RESEARCH STATION.

Paddock No. 8.

	Rate of Superphosphate/acre.			Percentage of no superphosphate plots as compared with	
	Nil.	56	112		
	Bus.	Bus.	Bus.	56 lb.	112 lb.
Year.	acre.	acre.	acre.		
1941	26.9	28.8	28.1	93	96
1943	27.9	32.9	34.1	84	85

Total superphosphate applied prior to 1941, 970 lb./acre.

WONGAN HILLS RESEARCH STATION.

Paddock No. 1E.

1941	13.0	16.4	17.3	79	75
1943* ..	4.7	5.0	5.2	94	90

*1943 yields affected by rust.

Total superphosphate applied prior to 1941, 747 lb./acre.

TABLE VI.

Rate of Superphosphate Experiment.

1943 Series.

Research Station.	Paddock.	Rate of Superphosphate Application lb./acre. Nil. bus./ac.	Nil. %	40 bus./ac.	40 %	80 bus./ac.	80 %
Merredin	1	26.9	93	28.8	100	28.2	98
Wongan Hills ..	2E	4.6	64	6.7	100	8.9	130

Total previous applications of superphosphate prior to 1943.

Merredin, paddock 1—1,335 lb. per acre.

Wongan Hills, paddock 2E—515 lb. per acre.

TABLE VII.

YIELD OF WHEAT PER ACRE AND PER INCH OF RAIN FALLING DURING THE GROWING PERIOD AT THE RESEARCH STATIONS WITH REDUCED SUPERPHOSPHATE APPLICATIONS IN 1942 AND 1943 IN COMPARISON WITH PREVIOUS YEARS.

Research Station.	Year.	Rainfall May–October.	Yield of Wheat. per acre.	Yield of Wheat. per inch of rain.	Superphosphate Application per acre. lbs.	Superphosphate Application per acre. grade %
		inches.	bus.	bus.	lbs.	grade %
Wongan Hills	*1943	9·12	10·1	1·10	40	18
	1942	12·33	12·9	1·05	70	18
	1941	10·77	13·9	1·29	120	23
General Average	1925–1941	10·60 (range 8·20–16·27)	14·7 (range 8·2–17·6)	1·39 (range 0·88–2·6)	120	23
Merredin	†1943	9·13	24·7	2·70	40	18
	†1942	8·40	23·3	2·78	60	18
	†1941	10·20	27·8	2·72	112	23
General Average	1922–1941	7·92 (range 5·54–11·13)	17·4 (range 2·9–27·7)	2·20 (range 0·46–3·4)	112	23
Salmon Gums ‡	1943	6·75	8·3	1·20	40	18
	1942	9·61	20·1	2·09	68	18
	1938	11·00	21·1	1·92	112	23
	1939	8·03	15·9	1·98	112	23
General Average	1927–1941	7·87 (range 5·22–13·05)	11·8 (range 6·8–21·1)	1·50 (range 0·7–2·6)	112	23
Avondale	1943	12·51	20·2	1·61	40	18
	1942	11·31	19·9	1·76	60	18
	1941	11·08	17·1	1·54	90	23
General Average	1925–1941	12·66 (range 7·47–17·14)	15·1 (range 9·5–21·8)	1·21 (range 0·5–2·6)	90	23
Chapman	§1943	10·55	13·8	1·30	40	22
	§1942	15·27	3·1	·20	70	22
	1941	14·74	13·4	·91	112	23
General Average	1917–1941	15·56 (range 9·39–26·86)	14·0 (range 5·0–18·0)	·90 (range 0·3–1·8)	112	23

* 1943 results affected by rust incidence.

† Bencubbin bulk crops only.

‡ 1940 and 1941 yields low due to drought conditions. 1943 yields affected by rust and storm damage.

§ 1942 yields reduced by heavy weed growth (good pasture year). 1943 yields reduced by rust incidence.

Agricultural Broadcasts.

The following programme of Agricultural Talks has been arranged for the July-September quarter and will be broadcast from Stations 6WF and Regionals at 9.15 p.m. each Thursday.

Date.	Talk Prepared by:	Title.	Summary.
	1.—FARMERS IN A CHANGING WORLD.		
July 27	A. S. Wild, Executive Officer, District War Agricultural Committees	District War Agricultural Committees	An account will be given of the constitution, development, and functions of D.W.A.C.'s. in Western Australia.
Aug. 24	A. M. Stewart, Lecturer in Agriculture, University of W.A.	Climate and Agriculture	The effect of climate in forming the pattern of agriculture will be discussed with special reference to Western Australia.
Sept. 21	L. W. Samuel, Cereal Research Officer, Department of Agriculture	Modern methods of testing wheat for flour strength	The speaker will show how the cereal chemist has been able to assist the plant breeder by evolving scientific methods for testing flour quality, and will also indicate the value of these methods to the miller and baker.
	2.—TOPICAL ITEMS.		
July 4 Aug. 3 Aug. 31 Sept. 28	G. K. Baron Hay, Under Secretary for Agriculture, will discuss current events in agriculture.		
	3.—FARMERS' FORUM.		
July 11 Aug. 10 Sept. 7	Discussion on topics submitted by farmers is arranged by G. A. Currie, Professor of Agriculture, University of W.A.		
	4.—TECHNICAL TALKS.		
July 20	L. W. Mahaffey, Assistant Veterinary Pathologist, Department of Agriculture	Mastitis and Contagious Abortion of Dairy Cows	Prospects for achieving contro of these two diseases will be discussed.
Aug. 17	E. T. Morgan, Officer in Charge, Potato Branch, Department of Agriculture	Topical Hints for the Vegetable Garden	The main seasonal activities in the vegetable garden will be outlined.
Sept. 14	H. R. Powell, Superintendent of Horticulture, Department of Agriculture	Registration of orchards — large and small	Events leading up to the passing of the Plant Diseases (Registration Fees) Act, and results that have been achieved from the moneys expended in the control of Fruit Fly will be discussed.

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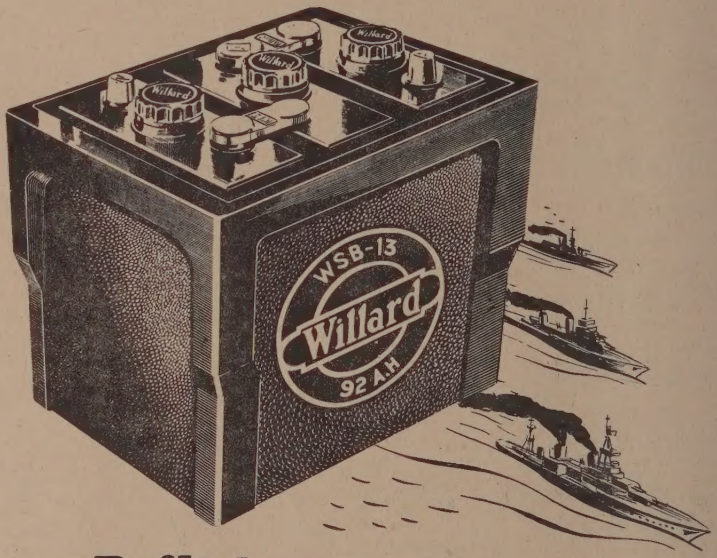

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